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APRIL 1ST, 1900.

SKULL OF ARCHELON ISCHYROS Wieland. × ⅕.

THE

AMERICAN JOURNAL OF SCIENCE

[FOURTH SERIES.]

ART. XXIII.—*The Skull, Pelvis, and Probable Relationships of the Huge Turtles of the Genus Archelon from the Fort Pierre Cretaceous of South Dakota;* by G. R. WIELAND. With Plate II.

THE marine turtles of the Fort Pierre Cretaceous of South Dakota not only represent the most gigantic species known, but also are of much importance as including undoubted descendants of *Protostega* from the underlying Niobrara Cretaceous, in common with which they may be regarded as ancient relatives of *Dermochelys*.

The first of these turtles was discovered and collected by the writer in 1895. The nearly complete carapace, pectoral girdle and limb bones of this specimen were described in this Journal (13)* the year following as those of the new genus and species *Archelon ischyros*. Additional material collected in 1897 and 1898, and in part here described, proves this determination to have been correct, although in describing the fine plastron of the first specimen secured the generic name *Protostega* was needlessly substituted (15). This was done in deference to high authority, but careful comparison made possible by new material of both *Protostega* and *Archelon* places beyond further question the validity of the latter genus.

The Skull of Archelon Ischyros Wieland.

The skull, the description of which is here given, was secured by the writer in the summer of 1897, and belongs to the second specimen discovered, this being nearly complete. Notwithstanding its gigantic size, it represents a turtle only three-fifths as large as specimen I. A fragmentary specimen (III)

* See references on p. 250.

indicates a turtle 4·25 meters long with a cranial length of fully 1 meter.

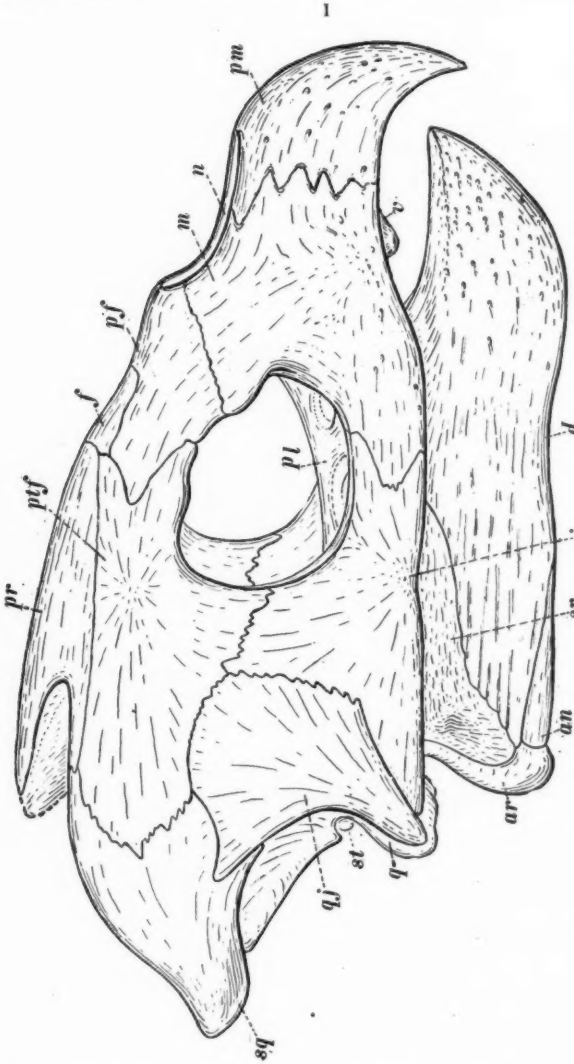

FIGURE 1. Skull of *Archelon ischyros* Wieland, $\times\frac{1}{3}$; *an*, angular; *ar*, articular; *d*, dentalium; *f*, frontal; *j*, jugal; *m*, maxillary; *n*, external nares; *pf*, prefrontal; *pl*, palatal; *pm*, premaxillary; *pr*, parietal; *ptf*, postfrontal; *q*, quadrate; *qj*, quadrato-jugal; *sq*, squamosal; *st*, columella auris in stapedial notch; *sr*, surangular; *v*, vomer.

The main features of the present skull are well represented in Plate II, based on a photograph of it as excellently mounted

by Mr. Hugh Gibb, and now on exhibition in the Museum of Yale University. The plate is carefully interpreted in fig. 1. Still other features are shown in figs. 2 and 3, which are necessarily somewhat diagrammatic.

Notwithstanding considerable lateral compression of the posterier portions, this skull is an unusually good one, all the main details needed for a restoration being well preserved. It only fails in the region of the brain cavity and the posterior extremity and connections of the vomer. Its description and comparison with its nearest known relative and ancestor *Protostega gigas* from the Kansas chalk has been made all the more exact and satisfactory by the courtesy of Prof. W. M. Wheeler and Dr. E. C. Case, who generously placed in my hands for purposes of comparison the exceptionally fine material so ably investigated by the latter (5). This represents various disarticulated elements of the skull and a fine mandible. Between the two specimens the skull of these important forms of the Cretaceous may now be known with essential completeness. The description of parts follows.

The Premaxillaries.—These elements are strongly coössified and comparatively narrow laterally, but long and massive. The narial border is rounded and horizontal. The dental border is posteriorly less developed into a cutting edge than in other turtles, but anteriorly runs out into the most strongly decurved beak known in any turtle, the aspect being that seen in birds of prey. The surface of the beak especially is deeply pitted, and in life must have been covered by a horn sheath of the relative decurvature and strength of that of the eagle. There is only a shallow excavation for the reception of the mandibular beak.

The great length and other details are the exact antithesis of the short and notched premaxillaries of *Dermochelys* with a persistent suture. The inner features and union with the vomer are shown in fig. 2. The boundaries are, in spite of all disparities, essentially similar to those seen in *Dermochelys*.

The Maxillaries.—The general maxillary outline is that of a broad Y lying on its side, the fork forming the anterior orbital boundary, and the wide base extending forward to an unusual distance. Much of the great cranial length is due to the elongated maxillaries and premaxillaries.

The narial border is only moderately upcurved to aid in the formation of the greatly elongated external nares, which face upwards and but slightly forwards, being much more nearly horizontal than in most turtles.

The dental border is continued by the maxillary as a low cutting edge which soon becomes rounded and continues so to junction with the jugal. It should be noted here that the

entire dental border is peculiar; firstly, because of the decurved premaxillary; secondly, because of the very slight concavity of the vomeral region, and the continuation of the dental border of the jugal as a rounded edge, which instead of ascending is most depressed at its junction with the quadrato-jugal, as will be again noted in the description of the latter elements.

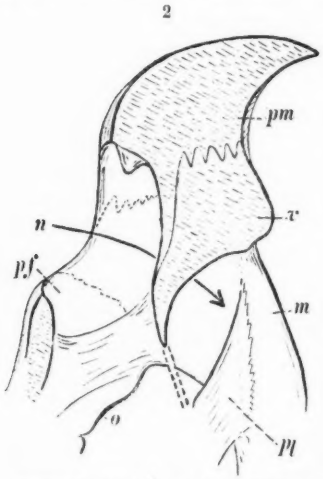

FIGURE 2. *Archelon ischyros* Wieland. Median vertical section through anterior region of skull × $\frac{1}{5}$; *m*, maxillary; *n*, narial opening; *o*, orbital boundary; *pf*, prefronto-nasal; *pl*, palatal; *pm*, premaxillary; *v*, vomer.

The maxillaries do not rise as high relatively to meet the prefrontals as is usual. There is in this conformation a suggestive resemblance to *Lytoloma* (*chelone*) *longiceps* Owen.

The Jugals.—These elements are subtriangular in outline, the basal side being longest, and extending back to the lower extremity of the quadrato-jugal as an un-notched nearly straight, somewhat depressed and rounded border. The depression of the jugal is quite unique and gives great length to the unusual dental border thus formed.

With the postfrontal the jugal forms the posterior two-thirds of the orbit, the orbital border being distinctly flattened and from 2^{cm} broad posteriorly to $3{\cdot}3^{cm}$ broad anteriorly. Only the extreme anterior extension articulates with the palatal, making the boundaries those of *Thalassochelys* and not like those of *Dermochelys*.

The Quadrato-jugals (Paraquadrate of Siebenrock 12).—These bones present exteriorly a large gently convex surface of broadly crescentic outline. The concave posterior border stands at a right angle to the outer surface and is 4^{cm} broad, forming a symmetrical surface with the quite similar posterior orbital boundary noted above. See fig. 1.

The quadrate is fortunately present in the specimen of *Protostega gigas* studied by Case, who thus describes it (5, page 27): "The quadrato-jugal of the right side is triangular in general outline. The posterior edge is concave and the whole bone is convex from above downward. The superior edge is narrow, and there is no prolongation of the antero-inferior portion as in *Dermochelys* (5, Pl. V, fig. 7)."

The differences between these two quadrato-jugals are therefore striking. Firstly, the outer area of that of the present specimen, which as just stated is broadly crescentic in outline, is relatively more than double that of *Protostega*, which is isosceles-triangular in outline with the equal sides slightly concave. Secondly, the flat free posterior border just outside the articulation with the quadrate as seen in *Archelon*, is represented in *Protostega* by an oblique surface mostly taken up by the quadrate suture. Lastly, the articulations must be essentially different. Since the outline in *Protostega* is distinctly triangular, the union with the jugal and post-orbital is by two sutural lines making an angle of 60° with each other, instead of by a long curved sutural boundary as in *Archelon*. Now since the upper of these sutural lines is nearly horizontal, and the general outline in *Protostega* that seen in *Dermochelys*, it is probable that the latter and *Protostega* agree in squamoso-jugal union. On the contrary, in *Archelon* there is marked squamoso-jugal separation. For reasons which I have pointed out elsewhere I do not lay great stress upon squamoso-jugal union or non-union alone (13). But the more salient fact to be borne in mind is that the great differences in general conformation compel accompanying variations in the jugal, parietal, and squamosal which are fundamentally generic.

The Squamosal.—This element is also present in both the Kansas material and the present specimen. The anterior portion extends upward to meet the parietal as a long narrow band nearly covered by the post-frontal, and does not expand nearly so much as in *Protostega*. The articular surface for the quadrate is placed well up on the interior side, more as in *Dermochelys* than in either *Protostega* or *Thalassochelys*. The lower border is shallow sigmoidal in outline and the posterior extension instead of ending bluntly as in *Protostega* runs out into a heavy rounded point somewhat as in *Trionyx spinifer*. As in *Protostega*, there is however no posterior inferior grooving of this extension.

The Prefrontals.—These are somewhat rhomboidal in outline. The junction with the postfrontal is long and prominent, and much as in *Dermochelys*. Of the four elements bounding the orbit the prefrontal takes least part. The prefrontals extend much further back from the external nares than in *Dermochelys*, the general resemblances being intermediate to the latter and *Thalassochelys*.

The Frontals.—These bones are narrow and relatively elongate. As the cranial roof underwent some crushing, it is difficult to discern the precise position of the parietal boundary. Resemblances *Thalassochelan*.

The Postfrontal.—The markings and boundaries of this

element are very distinct. It has an especially broad posterior development. Anteriorly it is greatly strengthened by the heavy post-orbital border, which runs up internally as a sharp but heavy buttressing ridge full 2·5^{cm} high in its middle part, and not disappearing wholly until the parietal is reached. No such ridge is present in *Dermochelys*, though a similar one of much less development is seen in *Thalassochelys*. The boundaries are approximately those of the latter form, union with the quadrato-jugal being very distinct.

The Parietals.—These were deeply escalloped posteriorly, nearly as much as in the *Chelydridæ*. As they had been subjected to crushing their outlines were not so distinct as in the case of the other external elements of the skull. Most unfortunately the vexed question as to descending processes of the parietals and parieto-pterygoidal union can not be definitely settled from the present specimen. There certainly was some, if not a strong development of these processes.

Both Baur and Case (1 and 5) have stated that there were strongly developed descending parietal processes uniting with the pterygoids in *Protostega*.

Whether or not the absence of these processes in *Dermochelys* is as important anatomically as convenient in classification, it is to be hoped that future material will determine what the exact condition was in these Dakota descendants of *Protostega*.

The Quadrates.—These are both present in fair condition and but slightly crushed out of their natural articulations. They are short and unusually massive, particularly the posterior border as it extends from the stapedial notch to the squamosal. A portion of the right stapes was still to be seen in the stapedial notch. As implied by the differences between the quadrato-jugal and squamosal of *Archelon* and *Protostega* as pointed out above, the aspect of the quadrate and its boundaries as seen in the present fossil must vary sharply from that of *Protostega*. The quadrates of the latter are illustrated by Case (5), while those of *Archelon* are seen as thrust slightly back in Plate II.

The Vomer.—The vomer is present in place and is remarkably developed. It is illustrated in fig. 2. As in *Protostega* (5) the anterior relations are distinctly *Dermochelan*, the vomer and palatines not roofing the posterior nares. But with these boundaries resemblance to this form ceases. Conforming to the great development of its anterior bounding elements, the vomer is unusually massive. It takes part in the palatal surface as a prominent conical projection in front of the posterior nares 2^{cm} high. Taken in conjunction with the descending premaxillary beak, this is quite the reverse relation to that seen in *Colpochelys Kempii* Garman, which has a flat

palate and no decurvature of the premaxillaries, but an upturned lower jaw with a prominent cone at the inner vertex of the ramial angle.

The superior surface of the vomer forms a distinct saddle contracting as it rises from beneath the overlap of the premaxillaries and passes back to support the inner buttresses of the prefrontals, between which it appears to end. Whether this was the natural condition could not be precisely determined. There is a bare possibility that the vomer did not pass back to form the usual vomero-palatal union. But whether this was the case, or whether the palatals sent a median branch far forward must for the present remain undetermined. The posterior nares however were not bridged by a nether vomero-palatal union, the condition being, owing to the deep gap between the palatals and the prominence of the vomer, intermediate between *Dermochelys* and *Eretmochelys*. Vomero-premaxillar union is stronger than in either the latter genus or *Argillochelys*.

Main Features of the Palatal Aspect.—These are distinctly shown in fig. 3. The only doubtful points are the exact size of the small basisphenoid and the boundaries in the vomero-palatal region just mentioned. Anteriorly the relations are partly *Dermochelan;* posteriorly they are *Thalassochelan*, with the exception of the basal processes of the basioccipital, which are heavy and project downwards and outwards as in *Dermochelys*. They are however much longer antero posteriorly than in this form.

There is a continual reminder that we have here to deal with a remarkable blending of the relations seen in the two genera just mentioned, with certain unusual characters. Especially the great development of the jugal nearly cutting out the quadrato-jugal in the basal view will be noted. Also the girder-like palatals are quite unique, forming a prominent

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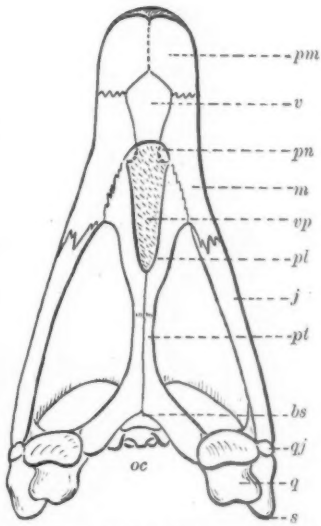

FIGURE 3. *Archelon ischyros* Wieland. palatal view × about $\frac{1}{16}$. *pm*, premaxillary; *v*, vomer; *pn*, posterior narial opening; *m*, maxillary; *vp*, the uncertain vomero-palatal region; *pl*, palatals forming a girder-like structure; *j*, jugal; *pt*, pterygoid; *bs*, basisphenoid; *qj*, quadrato-jugal; *q*, quadrate; *s*, squamosal; *oc*, occipital condyle.

V-shaped bridge, with any vomeral connection very deeply set in the skull. (Compare figs. 3, 4, and 5.)

*The Mandible.**—This was present in position and was quite perfect with the exception of the posterior elements of the left ramus, which were dissociated, only the surangular being recovered. The measurements appended may be taken as quite

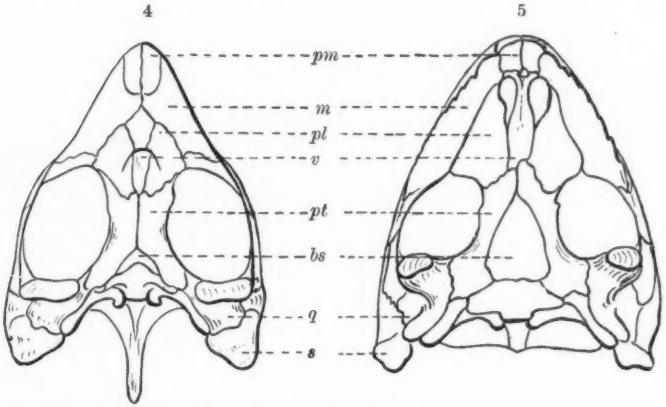

FIGURE 4. *Thalassochelys caretta*, palatal view of skull × 1/5.
FIGURE 5. *Dermochelys coriacea* " " " × 1/5.
pm, premaxillary; *m*, maxillary; *pl*, palatal; *v*, vomer; *pt*, pterygoid; *bs*, basisphenoid; *q*, quadrate; *s*, squamosal.

accurate, the complementary and articular being the only parts much altered by pressure. As the latter is very much flattened and the parts bounding it but little compressed, it may not have been well ossified.

From the apparent shortness of the rami, no less however than in the land turtle *Macrochelys Temminckii*, it may be fairly inferred that both the articular and the articular face of the quadrate were heavily encased in cartilage. This is also suggested by the roughened to spongiose appearance of both these parts. The horn sheath of the beak must also have been very heavy and somewhat upturned.

The general relationship of the present form to *Protostega* is strongly exemplified by the lower jaw. The presplenial of Baur (2) is however apparently less prominent than in that fossil (see Case, 5), the suture between it and the splenial not

* I retain the original nomenclature for the mandibular parts, not being as yet able to reconcile that proposed by Dr. Baur (2) with the conditions found in the Testudinata, and hoping later to present a paper on the homologies of the reptilian lower jaw.

being distinct. The presplenial region has rather the appearance of being a long anterior projection of the splenial (Baur's angular). On the contrary, the angular is a little broader and extends farther forward than in *Protostega*. Again, the narrow but nevertheless robust aspect of the anterior or symphysial portion of the dentary in *Archelon* is notable. Relatively to length the symphysial depth is great, and the weight of this portion of the jaw suggests a hammer-like action against the palatal cone. This would have been very effective in the crushing for food of large mollusca and crustacea, if perchance the Archelones were in any wise similar in feeding habits to existing carnivorous sea turtles.

Another well marked character is the persistent symphysial suture. While in half grown forms of *Protostega* this suture is wholly obliterated, in the present specimen, which may have been from adult to three-fifths grown, the rami readily separated on this line. So pronounced a suture is rare.

The ramial angle, which is 50° in *Thalassochelys* and *Dermochelys*, and 40° in *Protostega*, may not have been more than 25° in *Archelon*. The latter is a very narrow form, and the vertex of the rami forms a nearly sharp instead of rounded angle.

It is scarcely necessary to compare further. There is certainly more resemblance in the mandibulum to *Thalassochelys* than *Dermochelys*, but withal intermediate characters as in other parts of the skull.

General appearance of the skull.—The skull of *A. ischyros* is long in proportion both to the body and to its width, but nevertheless massive. There is in the deeply notched parietals, the decurved beak, and the depressed vicious-looking forehead, a distinct reminder of the features in such carnivorous land turtles as the *Chelydridæ*. Every relation bespeaks a ferocious form. So far as may be inferred from physiognomy it is easy to conceive this turtle with his powerful pinching and clasping beak, as preying not only on crustaceans, but even upon the larger fishes and reptiles of the Cretaceous seas.

The turtle to which this skull belonged was not more than ten feet in length, but had a remarkably broad and robust form. The flippers were short, broad, and of great power.

Measurements of the Cranium of Archelon ischyros Wieland.

(From a cotype approximately three-fifths the size of the type.)

	M.
Greatest length	·72
Width taken across the maxillo-premaxillar suture	·138
Width across middle of vomer	·145

Width through orbits	·22±
Height through center of narial opening	·095
Height directly back of narial opening	·17
Parietal height (greatest)	·28±
Width of narial opening	·07
Length of " "	·12
Greatest length of orbit	·15
" width "	·115
Length of the inferior edge of the premaxillary	·11
Length of inferior edge of the maxillary	·20
Length of inferior edge of jugal	·23
Length from extremity of beak to posterior inferior extremity of the quadrato-jugal	·58
Distance from tip of beak to antorbital border	·24
Least distance from postorbital border to the posterior border of the quadrato-jugal	·166

Measurements of the accompanying Mandible.

Greatest antero-posterior length	·465
Width across articulars	·25±
Antero-posterior length of symphysis	·12
Width at vertex of ramial angle	·155
Depth of symphysis at vertex of the ramial angle	·11
Extreme length of dentalium	·42
Extreme length of angular (lower outer surface)	·14

The Pelvis of Archelon ischyros.

The pelvis here described is entire, and in nearly perfect condition. As collected the parts were imbedded in an indurated marl in their natural position, with the exception of the ilia; which were slightly inclined laterally.

The notable features of the pelvis figured here are the great width, greater than the antero-posterior length, the very broad and symmetrical ectopubic expansion, and the diminutive size of the obturator foramen, which is entirely closed by the entopubis and ischium with the consequent reduction of the inter-obturator cartilage from a band to a small and solid rhombic area with concave sides. These are quite the reverse of the relations seen in *Thalassochelys*. To the general outline of the pelvis of *Dermochelys* there is strong resemblance, with the important exceptions that in the latter the ilium is longer and slenderer, while the obturator foramen though much reduced in size is not enclosed.

The ectopubis increases quite regularly to its greatest thickness at the heavy anterior border. The entopubis is likewise thickest distally, that is near the median line.

The ischia are short and broad, the middle anterior portion extending inward and forward to meet the pubis.

The ilia are short and robust, and curved into distinct elbows, the dorsal angles of which are very prominent, though ligamental attachment was confined to the distinctly rounded distal ends.

There are few pelves of fossil marine turtles known with sufficient exactness to make a close comparison with the present beautiful specimen wholly satisfactory. It no doubt conforms quite nearly to the pelvis of *Protostega* which has been figured

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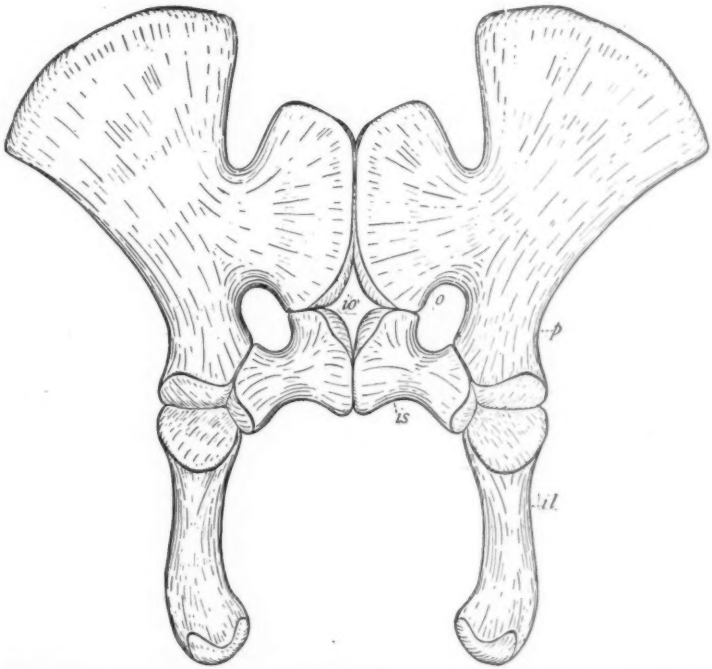

FIGURE 6. *Archelon ischyros* Wieland (type specimen). Ventral view of pelvis of specimen 12 feet in length, ¼ natural size; *p*, pubis; *il*, ileum; *is*, ischium; *o*, obturator foramen; *io*, interobturator cartilaginous area.

by Case, though the specimens he examined did not disclose the interesting conformation of the obturator foramen.

The presence of this feature, still seen in certain land turtles, in distinctly marine turtles of the Mesozoic, is certainly interesting, and may be regarded as a persistent character inherited from a land ancestry.

Measurements of the pelvis of Archelon ischyros Weiland (type).

		M.
	Extreme antero posterior length	·79
	Extreme width	·81
	Width taken across the acetabular surfaces	·46
	Shortest diameter of obturator foramen	·05
	Longest diameter of obturator foramen	·08
	Acetabular width	·12
	Acetabular length	·14
Pubis	Antero posterior length	·46
	Width, greatest	·405
	Greatest thickness (acetabular)	·175
	Antero-posterior width of entopubis	·25
	Thickness of entopubis (distal)	·07
	Thickness of ectopubis (distal)	·04
Ischium	Extreme length	·14
	" internal width	·15
	" external "	·10
	Width at middle of shaft	·06
	Thickness of " " "	·033
Ileum	Extreme length	·30
	" width of the acetabular surface	·093
	Thickness (least) at middle of shaft	·046
	Thickness (greatest) at middle of shaft	·105
	Greatest distal diameter	·095
	Least " "	·06

Archelon Marshii, sp. nov.

A second species of the genus *Archelon* is indicated by a specimen collected by the writer on the east side of the Cheyenne River in the Bad Lands proper in August 1898. Like the others, this specimen was found in the uppermost Fort Pierre Cretaceous, just beneath the Miocene or White River formation.

It consists in the plastron, humerus, ribs and a number of marginals indicating a turtle of great size, probably 11 feet in length. The humerus is rather straighter than in *A. ischyros*, and the plastron is relatively more massive, being fully one half thicker than in that species. As a slight token of respect this species is named in honor of Professor O. C. Marsh, to whose interest the Museum of Yale University is indebted for the possession of these gigantic *Testudinates*.

Position of the Genus Archelon.

While the genus *Archelon* presents many intermediate characters and strongly supports the view that *Dermochelys* belongs to the *Crpytodira*, as strenuously insisted upon by

Case in his discussion of the relationships of *Protostega* (5), its exact position may not yet be asserted positively. Bearing in mind that the turtles are an ancient highly specialized and numerous group of great constancy of form, it becomes both convenient and necessary to separate genera and families on less distinct anatomical differences than in the case of more variant orders. Moreover more exact knowledge of the fragmentary material of the Mesozoic is the first requisite; for many forms will be found like the present, disposing of old questions only to raise new ones.

In general I am however inclined to accept Cope's *Protostegidæ* (7) as containing the genera *Protostega* and *Archelon*. It is scarcely necessary to say, however, that there is a vastly greater interval between the *Dermochelyidæ* and *Protostegidæ* as thus constituted, than between the latter and the *Cheloniidæ*. I would lay especial stress upon the necessity of recognizing this general fact.

The position of *Protosphargis Veronensis* Capellini (3) is very doubtful, firstly because its skull, nuchal and fore-arm are unknown, and secondly because of the uncertainty concerning the validity of the *paraplastron*, as I have termed what I suppose represents the fused anterior plastral elements in *Protostega* and *Archelon* (15).

While the latter genera appear to be much too strongly specialized to represent more than a Cretaceous offshoot from the *Dermochelan* line of descent, *Protosphargis* may possibly be exactly in this line. The form of the plastron especially suggests such a position. The center of greatest interest has therefore in large measure shifted to *Protosphargis*. The discovery of further specimens of this genus will be of the first importance.

Attention should here be drawn to the interesting determination of the marginal series of *Protosphargis* by Capellini (4). I may mention too that a single marginal was figured in the first description of *A. ischyros* (13) which is wholly characteristic. The entire marginal series in this form is unusual in the spiny development of both the dorsal and ventral interior marginal borders, which are strongly spine-set after the manner of the plastron. Case has figured a portion of the marginal series in *Protostega* (5), but his material did not bring to light such a full development of spiniferous marginalia as is seen in *A. ischyros* and *Marshii*. That these spines represent the disappearing remnants of a normally developed carapace is a reasonable supposition and nothing more. But whether representing advancing or receding ossification the slender and untoothed marginals of *Protosphargis* indicate a sharp interval in development between these forms. The latter is undoubtedly a well marked genus.

With increasing knowledge of *Protostega* and its allies, that most interesting of questions pertaining to the *Testudinata*, the origin of *Dermochelys*, remains quite as enigmatic as ever. Hence only the following tentative classification can now be presented, the writer hoping to again attack the general subject at a future time.

Family—PROTOSTEGIDÆ Cope.

Genera—*Protostega* and *Archelon*.

{Doubtfully belonging to the *Protostegidæ*, *Protosphargis Veronensis* Capellini (3, 4), and still more doubtfully *Pseudosphargis ingens* von Könen and Dames (8).}

Synopsis of Characters of the Protostegidæ.

Marine turtles with carapace of medium curvature. Neuralia and pleuralia thin and investing the ribs but slightly. Marginalia usually spiniferous on interior borders. Plastral elements of medium development with numerous digitations. Normal epiplastron unknown, the three anterior plastral elements probably uniting into an entepi- or paraplastron. Body enveloped in a leathery hide? Skull intermediate between that of the *Dermochelyidæ* and the *Cheloniidæ*.

Genus Protostega Cope.—Squamoso-jugal union probable. Quadrato-jugal triangular. Mandibular rami coössified. Radial process of humerus strong. Carpals and tarsals unknown. Complete outline of obturator foramen unknown.—Only species *P. gigas* from the Niobrara Cretaceous of Kansas.

Genus Archelon Wieland.—Quadrato-jugal strongly united with the postfrontal, and of crescentic outline. Mandibular symphysis remaining distinct. Radial process of humerus weak, ectepicondyle strong. Carpals and tarsals undescribed. Obturator foramen small elliptical and enclosed.—Type of the genus, *A. ischyros* Wieland. Second species, *A. Marshii* Wieland. Humerus straight and robust. Plastron unusually heavy. Both species from the Upper Fort Pierre Cretaceous of South Dakota.

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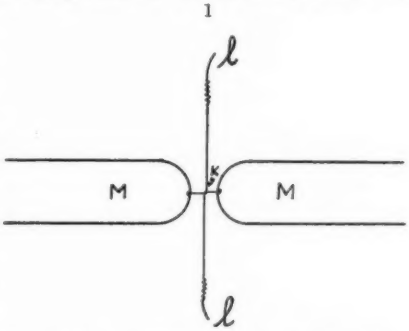
Yale Museum, New Haven, Conn.,
Feb. 20, 1900.

Art. XXIV.—*Application of the Radio-Micrometer to the Measurement of Short Electric Waves;* by G. W. Pierce.

Klemencic* first made use of the thermal-junction as a means of measuring electric waves. His device consisted of two thin sheets of brass, M, 10^{cm} broad and 30^{cm} long, placed 3^{cm} apart and having soldered to them respectively a very fine platinum and a very fine platinum-nickel wire, which were crossed at k and were thence conveyed off at right angles and soldered at their other ends to the leads, l, of a sensitive galvanometer. This resonating system was fixed at the focal line of a suitable cylindric metal reflector. Electric oscillations between M and M produce heating at the knot, k, which gives rise to a thermo-electromotive force at the knot and consequently to a current through the galvanometer. By the use of this instrument, Klemencic has studied the reflection of electric waves from metals and sulphur, but on account of the length of his waves, he has not been able to obtain results possessed of quantitative accuracy.



Employing a similar device of smaller dimensions, Cole† has measured the coefficients of reflection from the surfaces of water and alcohol in the two principal azimuths, and from these coefficients has calculated, by the use of Fresnel's formulas, the index of refraction and the specific inductive capacity of these substances. Also, later,‡ Cole has measured by the use of a thermal junction the absorption of electric waves by water and alcohol. P. Lebedew,§ employing a slightly different form of thermal-junction, has worked with waves of still smaller dimensions, and has obtained important results.

In the present paper, a description is given of an apparatus

* Ignaz Klemencic: Ueber die Reflexion von Strahlen electrischer Kraft. Wied. Ann., xlv, p. 62, 1892.

† A. C. Cole: Wied. Ann., lvii, p. 290, 1896.

‡ Cole: Phys. Review, vol. vii, Nov., 1898.

§ Peter Lebedew: Doppelbrechung der Strahlen electrischer Kraft. Wied. Ann., lvi, p. 1, 1895.

that I have found to be useful in quantitative experiments on electric waves.

The Resonator.—For a receiving instrument I have employed a resonating thermal-junction like that of Klemencic and Cole; but instead of a separate galvanometer, I have made the thermal system a part of the suspension in an apparatus similar in other respects to the radio-micrometer of Professor Boys. This arrangement is shown in sectional diagrams in figs. 2, 3, and 4.

Fig. 2 is a vertical section through the suspension and perpendicular to the field magnet. Upon a base, *B*, provided with leveling screws, is placed a parabolic, cylindrical reflector,

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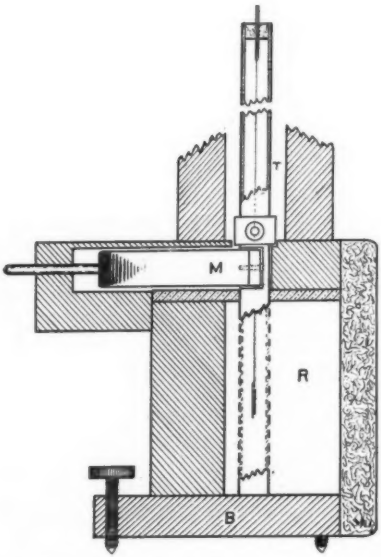

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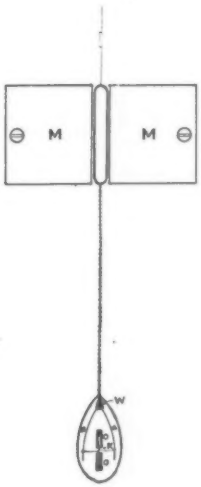
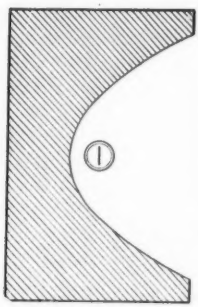


sawed from a block of wood and covered inside with a copper reflecting surface. The cavity formed by this reflector is marked *R*, and the opening of the parabola is at the right. Above the reflector and separated from it by a sheet of brass is a horse-shoe magnet, *M*, with pole pieces coming near together and projecting into the brass tube, *T*, which contains the fiber of the suspension. Within the reflecting cavity the continuation of this tube is of glass, shown by dotted lines. The parabolic reflector has a focal length of 2^{cm} and an orifice 16^{cm} wide by 13^{cm} high. The height of the pole pieces is $2{\cdot}5^{cm}$

and the distance from the bottom of the magnet to the thermal-junction is 6·7^{cm}. The pole pieces are 4^{mm} apart, and are covered with copper foil to prevent iron from getting on the coil.

A better idea of the suspension can be had from fig. 3, which is a section through the axis of the field magnet. The coil consists of a single loop, 2^{mm} wide, of number 34, *B* and *S*, silk-covered copper wire. After forming the loop, the ends of the wire are twisted together for a distance of about 5·5^{cm} downward and are then separated to form the lead-terminals *a*, *a*. The resonating system consists of two copper cylinders, *o*, *o*, 8^{mm} long, and 1^{mm} in diameter. These cylinders are about 1^{mm} apart, and to their nearer ends are soldered respectively a constantin and a manganine wire reduced by aqua regia to have a diameter of ·01 or ·02^{mm}.* These small wires are crossed at *k*, conveyed off at right angles and soldered to the leads, *a*, *a*, thus forming a closed circuit with the coil. The resonators, *o*, *o*, are sewed by silk threads to a mica vane, *v*, and the lead wires are fastened to the vane by sealing wax at *w*. The springiness of the leads keeps the finer wires in contact at *k*.



The clear space between the pole pieces of the field magnet is about 3^{mm}, the sides of the brass tube being cut away to admit them. The magnet, M, can be pulled back, withdrawing the pole-pieces, to allow the suspension to be lowered into the tube. When pushed forward again, it closes up snugly around the coil and prevents air currents from coming into the cavity in which is the suspension.

When electric waves of proper length enter the cavity, R, they are converged by the reflector and cause electric surgings up and down between the cylinders *o*, *o*, heating the thermal junction *k* and producing a steady current through the coil. Being in a strong magnetic field, the coil turns so that its plane makes a small angle with the axis of the magnet. These small deflections are read by an Elliott reading telescope of such good definition that tenths of a millimeter can be estimated with considerable accuracy.

The thermal-junction must be carefully protected from radiant heat. To effect this the magnet, the back of the reflector, and the suspension tube are covered by wood 3^{cm} thick; the opening of the reflector is closed by a sheet of

* For an explanation of the method of making these small wires, see Lebedew's paper, l. c.

cotton wool of about the same thickness; and the whole instrument is then put under a pile of felt 5 or 6^{cm} thick. The only part that is at all exposed is the mirror of the suspension, which is viewed through a double glass window, and is further protected by screens from lamps in the room and from the body of the observer.

The suspension is hung by a fine quartz fiber, of which the force of torsion serves as control. The weight of the system is ·27 gram, of which the mirror weighs ·05, and the resonating cylinders ·144 gram. The period of a swing one way is 3 seconds. The resistance of the thermal-junction is about 2 ohms.

It might be supposed that the sensitiveness of the instrument could be increased by making the coil of about 30 turns, which would give it a resistance equal to that of the thermal-junction. I have found, however, that the control by the field, due to the magnetic properties of the copper, is so great as to give a smaller sensitiveness with a large number of turns than with a single loop. This instrument, because of the resistance of the thermal-junction, cannot be made to have the extreme delicacy of Mr. Boys's original radio-micrometer.* It has, on the other hand, a sensitiveness that is not easily obtainable by the use of a thermal-junction with a low resistance galvanometer, as is shown by the following rough test:

A thermal couple of German silver and manganine wires of commercial size, when connected to a galvanometer with a figure of merit of 10^{-8}, gave a deflection of 2^{cm} when heat was focussed upon it from a distant lamp. The instrument described above with approximately the same heat, less the amount absorbed by the glass tube, gave a deflection of 40^{cm}; to obtain which the German-silver-manganine couple would have required a galvanometer capable of giving a deflection of 1^{mm}, at a scale distance of 100^{cm}, for a current of 5×10^{-10} amperes.

Another advantage of the D'Arsonval arrangement is that it can practically be made dead-beat and is unaffected by outside magnetic disturbances. This is important in the measurement of electric waves, since, on account of the variable nature of the source of the waves, throws instead of permanent deflections must be read; and to get consistent throws it is necessary to have the suspended system start from a state of rest, a condition difficult to attain with a sensitive galvanometer even when shielded. The instrument described above has kept its zero within a very small range for over a month, and after a reading is taken comes rapidly to rest, disturbed only by the slight tremors of the pier on which it is placed.

*C. V. Boys: Phil. Trans., vol. clxxx, A, p. 159, 1888–1889.

However, when the instrument was set up, it was at first violently influenced by an electrostatic action coming direct from the oscillator. This proved to be due to a small condenser that had been placed in series with the secondary of the induction coil for the purpose of diminishing the arc at the oscillator. By removing this capacity, and by coating over with tin foil the wooden cover of the top part of the receiving apparatus, a recurrence of this disturbance has been prevented.

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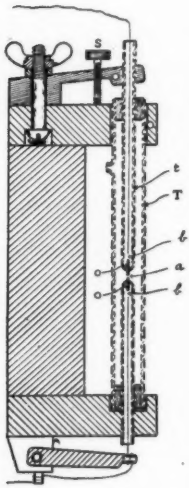


The Oscillator.—Reference is made to fig. 5. Two platinum cylinders, *O*, tipped with pieces of iridium, are fused into the ends of small tubes of thermometer glass, *t*. These thermometer tubes are passed through the rubber stoppers of a larger tube, T, for holding oil. The larger tube has a diameter of 2^{cm}, and by wooden braces is held at the axis of a parabolic cylindrical reflector of the same dimensions as that of the resonator. The distance between the platinum cylinders of the oscillator can be adjusted by means of the micrometer screw, *s*. Into the smaller tubes are brought two small platinum wires connected by copper leads to the secondary of an induction coil of medium size. These wires are separated by spark-gaps, *b*, from the platinum cylinders.

The spark-gaps, *b*, are about 2^{mm} long, and serve to isolate the platinum cylinders. Upon their length seems to depend in a slight degree the period of the oscillation, which by their adjustment can be made approximately equal to that of the resonator. The spark in oil, *a*, must be very short to prevent the damping out of the oscillations. The wearing away of the terminals at this gap is a source of great annoyance by changing this damping factor, and consequently changing the quantity of energy radiated as electric waves. Platinum is the only metal that I could fuse into the glass tubes that would not break the tubes under the heat of the spark, and platinum was found to wear away very rapidly, presumably on account of the action on it of the hydrogen freed by the decomposition of the oil. I have attempted to diminish this destruction of the oscillators by tipping them with pieces of iridium fused on with copper as a solder. The iridium disappears much more slowly than the bare platinum. Other oscillators I have tipped with silver, but the iridium serves better. However,

since only one of the terminals wears away, a pair consisting of one with a silver tip and one with an iridium tip is about as good as two of iridium. Also, the decomposition of the oil deposits carbon on the terminals, changing the oscillations by temporary short-circuits, making the readings irregular. I have not attempted to avoid this except by frequent renewal of the oil. It might perhaps better be done by forcing a continuous jet of oil across the spark. As a liquid dielectric for the spark, *a*, I have used vaseline oil; in this following the example of Mr. Righi.

The Break of the Induction Coil.—To get a strong, constant source of the waves, it is important to have an interrupter for the primary circuit of the induction coil that is rapid and uniform. To this end I have employed a motor-break of the Foucault type. A platinum rod, attached directly by an eccentric to the shaft of an alternating-current motor, is plunged up and down in a cup of mercury. The motor is of the type supplied by the General Electric Company to run their small portable fans, and makes about 1,500 revolutions per minute. The surface of the mercury is kept clean by a stream of water that flows continually over it—a device previously employed by Mr. Maclean* in this laboratory. In spite of these precautions I have not been able to obtain a constant source of waves; the oscillator slowly deteriorates, and the readings of the instrument get gradually smaller. This source of error is, however, quite regular, and in most of the work of comparing quantities can be fairly well eliminated by taking alternate readings and averaging.

For good adjustment of the oil spark-gap a deflection of 8^{cm} can be obtained with the oscillator at 50^{cm} from the resonator. For better regularity of the measurements, the spark was ordinarily adjusted so as to give between 1 and 3^{cm} deflections.

Quantitativeness of the readings.—At the outset the question arises as to what relation exists between the deflections of the instrument and the intensity of the radiations that produce them. We should suppose beforehand that these two quantities are directly proportional, for the deflections are proportional to the electromotive force at the thermal knot. This e.m.f. should be very approximately proportional to the heat developed there, which being of the dimensions of energy should be proportional to the intensity of the waves.

Attempt to test this point by depriving the oscillator of its parabolic reflector and measuring the deflections produced in the resonator at various distances from the oscillator presents difficulty; for, in the first place, if we start with the conclusions of Hertz's mathematical theory of the oscillator that the

* G. V. Maclean, this Journal, vol. viii, July, 1899.

intensity at a point is inversely as the square of the distance from the source, we obtain from a linear source and a parabolic receiving reflector an integral that is difficult to treat. In the second place, we cannot eliminate the difficulties arising from diffraction.

I have attempted in another way to get experimental evidence of the significance of the deflections of the receiving instrument. With the oscillator and the resonator both armed with their parabolic reflectors, the effect was measured of turning the oscillator to an angle, a, with the resonator about the common optical axis of the two reflectors. The oscillator was directly in front of the resonator at a distance of 52^{cm}, and the angle of turning was read off in degrees on the scale at the back of the reflector of the former. The headings of the respective columns are the angles of turning. In the columns are the corresponding deflections of the receiving instrument in millimeters. Alternate readings were taken.

0°	30°	0°	45°	0°	60°	0°	90°
12·2	9·8	12·4	6·9	11·2	4·2	10·4	1·5
11·9	10·1	12·2	6·4	11·6	4·2	9·5	1·1
11·0	9·4	12·0	6·6	12·5	3·9		1·2
11·6	8·9	11·9	6·6	11·3	3·7		
11·0	8·7	11·6		10·6	4·2		
10·5	8·5						
10·6	8·5						
10·3							
11·14	9·13	12·0	6·62	11·4	4·04	10·0	1·3
Ratio	·819		·552		·355		·13
							·16
							·17
							·15

Other values obtained for the last ratio

Averaging

Now if the wave is plane-polarized and we neglect the effect of the second metallic reflection on the nature of the polarization, we should have for the component of the intensity in the direction of the resonator the formula

$$I_1/I_2 = \cos^2 a.$$

But when the instruments were at right angles there was a small deflection remaining which was not accounted for by this formula. This was shown to be due to the waves, for a metallic screen interposed nullified it completely. Whether this effect is due to a mixed polarization of the waves or due to the action of the waves on the short, fine wires perpendicular to the resonating cylinders in the thermal-junction, it shows a component of

intensity at right angles to that accounted for in the above formula, and suggests the addition of a term $\cdot 15\sin^2 a$.

If this is done we have

$$I_1/I_2 = \cos^2 a + \cdot 15\sin^2 a.$$

With this formula, I have calculated the ratio of the intensities and placed them in the third column of the following table for comparison with the ratio of the deflections:

a.	d_1/d_2 obs.	I_1/I_2 calc.
0	1·	1·
30	·819	·79
45	·552	·575
60	·355	·362
90	·15	·15

It is seen that the observed values agree fairly well with those calculated from the formula. Though the experiment is not conclusive, it seems strongly probably that the deflections of the receiving instrument are proportional to the intensity of the waves.

The wave-length in this and the next experiment was $4\cdot4^{cm}$, measured by the method of stationary waves.

Transparency of Wood.—Mr. Righi has shown that certain woods transmit waves more freely when the grain is in one direction with respect to the oscillator than when it is in the perpendicular direction. Below is a short table of data confirming Mr. Righi's observation. A piece of pine board 22·4 centimeters square by 4·8 centimeters thick was interposed between the oscillator and the resonator, and readings were taken with the grain perpendicular to the direction of the electric oscillation, with the grain parallel to these oscillations, and then with the board removed. The readings are in millimeters, and the *dashes* indicate the order of taking the observations.

Out.		Grain perp.		Grain parallel.	
		13·4	———	8·0	——
15·4	——	12·8		7·9	
15·8		12·2		7·0	
17·1		12·2		7·0	
15·0		12·0		6·5	
14.5		10·5		6·9	
14·2		10·0		7·1	
14·2					
15·2		11·9		7·2 means.	

Percentage transmitted with the grain perp. is 78·3.
" " " " par. is 47·4.

The transparency of this board with the grain parallel to the electric oscillation is about 60 per cent of its transparency with the grain perpendicular. Another set of measurements gave for this quantity the value 59·2. For these two orientations, white oak and white wood show very small differences respectively in their transparencies. The striking characteristic of pine in this respect is undoubtedly due to difference between its electric conductivity in and across the grain.

A grating formed of strips of metal 2^{cm} wide and 2^{cm} apart was found to transmit 96% of the incident waves when the strips were across the oscillator, and 29% when the strips were parallel thereto.

A single rod of brass 3/16 inch in diameter, placed between the oscillator and the resonator parallel to the electric displacement, was found to screen off 40% of the waves.

These simple experiments are intended merely to show the adaptability of the apparatus to quantitative work with electric waves. Other investigations are in progress.

Jefferson Physical Laboratory,
Harvard University.

ART. XXV.—*Some remarks on the latest publications of Fl. Ameghino;* by SANTIAGO ROTH (Museo de la Plata).

IN the "Segundo Censo Nacional de la Republica Argentina," 1898, i, p. 111–125, Fl. Ameghino published a paper entitled: "Sinopsis Geologica-Palaeontologica," in which he gives a systematic account of the fossil-bearing deposits of Argentina. His divisions and correlations of the different horizons are so positive, that any one, who is not well acquainted with the geology of the Argentine Republic, must believe that they are well supported.

In July of the same year he published a supplement to this paper,* in which the sedimentary and eruptive formations between Bahia Blanca and the Cordilleras described by myself† have been inserted into his system.

In regard to the latter point I should like to express briefly my own views, which differ from those of Ameghino, since I fear that the latter may be accepted as well founded—as has happened in other cases—when I have left them unnoticed. For instance, I described the new species of *Toxodon elongatus*, which Mercerat has declared to be identical with *Toxodon giganteus*. The latter is founded upon a femur from Monte Hermoso, which, as may be seen at a glance, does not belong at all to the genus *Toxodon*. It was at first my intention to make no reply to this, but I have seen, much to my regret, that this failure on my part has induced Dr. Trouessart in his "Catalogus Mammalium" to give *Tox. elongatus* as a synonym of *Tox. giganteus*, and to let *Dilobodon* stand as a good genus. Trouessart, of course, could only follow the literature, since he did not possess any material for comparison, and the same reason explains numerous other errors in the "Catalogus" in respect to the Argentine fauna. Trouessart has taken all the doubtful facts given by Ameghino in good faith, although a part of them have been altered meanwhile by Ameghino himself.

Whoever has taken pains to compare Ameghino's dates in his different papers must surely be struck with the idea that they cannot be taken seriously, since he frequently changes his opinions, and abandons views he propounded very positively at first. Thus in 1889‡ he placed the Patagonian beds above the Santacruzian, Paranense and Mesopotamian, and called them Oligocene; in 1894§ he says, that the Santacruzian formation

* Sinopsis Geologica-Paleontologica, Suplemento (Adiciones y Correcciones) Julio, 1899, La Plata.

† Apuntas sobre la Geologia y Paleontologia de los Territorios Rio Negro y Neuquen. Anal. Mus. La Plata, 1898.

‡ Mamiferos fosiles de la Republica Argentina.

§ Enumeracion synoptique des espèces des Mammifères fossiles des formations éocènes de Patagonie. Buenos Aires, 1894.

lies above the classical Patagonian, and that the latter belongs partly to the Lower Eocene, partly to the Cretaceous. The Tehuelche formation has suffered a change still more incomprehensible; in 1889 (l. c.) we find it on top of the Pampean formation, which is, according to him, Pliocene, and consists of the stages: Ensenadense (Pamp. inf.), Belgranense (Pamp. med.), Bonaerense (Pamp. sup.) and Lujanense (Pamp. lacustre); the Tehuelche ought to be, accordingly, Quarternary, which is the opinion of others. But in his latest paper* he puts it in the Lower Miocene!

Ameghino has never seen any Patagonian deposits with his own eyes, and bases his divisions and theories, which he propounds in every case as well proved facts, upon the reports of other investigators, chiefly upon the alleged observations of his brother Carlos. There is no doubt that his present division will meet the same fate as all the rest: indeed, it will be shown that it is even less tenable than those given previously by him; and it is very significant, that he *begins already* new changes immediately after the conclusion of his latest paper.

As to the correlations of the formations investigated by myself in the territories of Rio Negro and Neuquen with this absurd division, I wish to make the following statements.

1. In the "Suplemento" he says: "*Piso Pyrotheriense.* Mr. Roth has observed very extensively the beds of this stage, which he designates as "Toba (tufa) cretacea," in the territories of Chubut and Santa Cruz, and has found in them, at different localities, bones of Saurians and Mammals." The fact is, that I have never been farther south than the Rio Deseado, and that I have never found, in these Cretaceous tufas, any remains of the Pyrotherium fauna described by Ameghino, but of a fauna entirely different from it. On my last voyage, however, I found representatives of a great number of genera and species belonging to his Pyrotherium fauna in deposits of a loess-like character and of much younger age, but so far no traces of the genus *Pyrotherium* itself. I have long doubted that the genus *Pyrotherium* is represented in the same beds with the other genera of this fauna, and the same doubt has been expressed by Mr. Hatcher, who has traveled several years in Southern Patagonia, and has made extensive collections. And, indeed, Ameghino, after having met Mr. Hatcher, changes his former ideas as to the Pyrotherium fauna. In the conclusion of his supplement (l. c., p. 13) he says in a supplementary note: "According to information sent to me by Carlos Ameghino regarding the explorations made during his last voyage from Puerto Deseado, it has now been settled that what we have called the Pyrotherium fauna consists really of

* Segundo Censo, etc.

two very different faunas, which have been mixed up by him, because the beds in which the remains were found, have been met with in such a position that there seemed to be no break between them. Now he has found them separated in certain localities, and lying unconformably to each other, and it is possible to recognize two faunas separated by a considerable geological interval. The true Pyrotherium fauna, which may be known henceforth by this name, is the younger and belongs to the Upper Cretaceous, while the older, in which *Pyrotherium* is wanting and which has been called by Carlos the Notostylops fauna, belongs to the Middle Cretaceous."

This new version does not agree with my observations, and it will finally be shown that *Pyrotherium* is not at all associated with these mammalian remains. The other genera, which he designates as belonging to the "Pyrotherium fauna" are positively *not* from those Cretaceous beds, which contain the remains of Mesozoic Saurians, but belong to Tertiary deposits, and have nothing to do with the Mesozoic mammals described by myself.

In all the papers in which Ameghino treats of this fauna, he states that remains of rodents are frequently found associated with it. Among the mammalian remains discovered by myself I was struck by the complete absence of rodents. Although I have found this fauna again on my last trip in various localities, I did not find in it remains of a single rodent. Of course, this does not prove that rodents are entirely wanting in this fauna, but since in other Mesozoic deposits no rodents have been discovered, it seems very probable that also in Patagonia this group did not make its appearance before Tertiary times.

2. I cannot understand what Ameghino means by his "Piso Sehuense," which, with the Piso Pehuenche and Pyrotheriense is said to constitute his Guaranitic formation. He associates in this stage all possible deposits which are mentioned also in other stages: for instance, he says, that a tufa-deposit belongs here, in which I have found associated with mammalian remains a skull of a species of *Megalosaurus*. The mammalian remains, he alleges, belong to the Pyrotherium fauna, that is to say, to the Piso Pyrotheriense, but the skull of *Megalosaurus* to the Piso Sehuense! For this skull he creates a new genus, *Longosaurus argentinus*, although he has never seen it, and says that a piece of a femur found by his brother near Rio Sehuen belongs to the same species. (The skull has been sent to London for determination.)

Further, he puts into this stage the marine deposit discovered by me near Roca on the Rio Negro, and says that the same is found well developed on the Limay and Pichpicuru Leufu, as well as on the Collon Cura. I have traveled in the country

near the Limay four times, and have never seen a trace of marine deposits, and the same results have been obtained by Drs. Moreno, Wehrli, Zabalowicz, Siemiradzki and others. On the Pichipicuru Leufu, Mr. Hauthal has met with marine deposits in the upper part; these, however, belong to the Lower Cretaceous and have nothing in common with those from Roca. On the Rio Collon Cura itself there are—as far as it has been explored—no marine deposits; but such deposits are present in what is called Angostura, several hours distant from the river. These, however, are of Jurassic age (Lias). These two marine deposits are no doubt much older than those near Roca, and it is impossible that they belong to one and the same stage. Upon what grounds Ameghino places the marine beds of Roca in his Piso Sehuense, does not appear in his paper.

3. Regarding the Tertiary tufa-deposits on the Collon Cura discovered by me, he says that they belong to the Patagonian formation. As to the latter, so much confusion prevails, that a more extended discussion, than is now possible, would be necessary to determine the validity of this correlation. It is sufficient to remark, that the tufas in question are of the same age as the marine beds on the coast near the mouth of the Rio Chubut, and that in both the same mammalian remains are found as in the Santacruzian. Ameghino bases his opinion, that the tufas of Collon Cura are older than the Santa-Cruz-beds, on the fact that remains of *Propachyrucos* and *Eutrachytheres* are present in them, which he regards as characteristic Cretaceous mammals. *Eutrachytheres*, however, or at least a very closely allied genus of the family *Typotheridæ*, is found in Patagonia in very much younger deposits, from which we have secured several species of the genus *Toxodon* and a species of *Megatherium*. *Propachyrucos* is so closely allied to *Pachyrucos*, found abundantly in the lower Pampean beds, that its presence in the Santacruzian is not at all strange. The very presence of these two genera, so highly specialized, in the so-called Pyrotherium fauna, is an argument for the young age of the latter, and if it were not for some more primitive forms associated with them, we could agree with Mr. Hatcher's opinion, that the Pyrotherium fauna is younger than the Santacruzian. But, as is shown by stratigraphical evidence, it is really older than the latter.

4. The sandstone-formation of the Rio Negro, which has been described carefully by Zapalowicz* and myself,† is placed by Ameghino in the Piso Rionegrense, which he believes to be Lower Miocene. Apparently his reason for this is, that he confuses the sandstone formation with the marine deposits, which are exposed in some places near Carmen de Patagones.

* Das Rio Negro Gebiet in Patagonien. Denkschr. k. Akad. Wiss. Wien, 1893.
† Apuntes sobra la Geologia, etc., 1898.

All the molluscs which he quotes from the Piso Rionegrense are found in the marine deposits of Chubut, which follow the coast up to the mouth of the Rio Negro, and which are much older than the Rio Negro sandstones.

This sandstone deposit has a very wide distribution in Patagonia, and extends as far west as the Cordilleras. I have found it in all cases immediately below the glacial bowlder formation, and it belongs no doubt in the uppermost Tertiary, and corresponds possibly with the Cape Fairweather beds of Hatcher.

5. The same seems to be true of the Piso Tehuelchense, which Ameghino puts also in the Lower Miocene. The marine deposits, however, which he refers to as belonging here, seem to be older.

Ameghino apparently has not the slightest idea of the stratigraphy of Patagonia, otherwise such confusion would have been impossible, and he would not have published the erroneous view that the Tehuelche formation, in which he includes the Patagonian bowlder formation, which is clearly Quaternary, belongs in the Lower Miocene!

I cannot enter upon a detailed discussion of the palaeontological part of his Sinopsis: the same confusion prevails here as in the geological part. He retains all the genera and species created by himself, many of which cannot stand in the face of a candid criticism; on the other hand, he declares many of those genera created by others to be synonyms of his own. For instance, without giving any proof he makes all the new species determined by me from the Tertiary deposits on the Collon Cura* synonyms of species described by himself from the Santa-Cruz beds, and he does the same thing with my Mesozoic mammals,† declaring all genera without exception to be identical with genera of his Pyrotherium fauna. Mr. Hatcher, who looked over some of the types of this latter fauna with Ameghino, when he was shown the Mesozoic mammalian remains of our collection, remarked that he had seen nothing like this fauna either in Ameghino's collection or during his travels in Patagonia, and that nothing of the kind was known to him from North America. Since Ameghino does not mention any facts supporting his allegations, there is no reason why I should cancel a single one of my genera, or why I should characterize them again. But in order to show how arbitrarily he acts, I reproduce here the figures of two species of Mesozoic mammals described by myself, and the figures of his species with which he says they are identical. I may mention also, that in several cases he declares a genus of which I possess only the upper jaw, to be identical with a genus of which he has only the lower, or vice versa.

* Apuntes, etc., 1898.

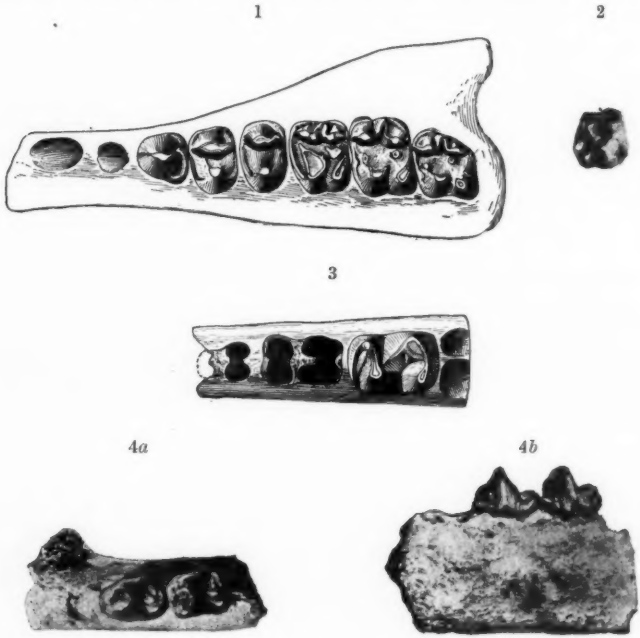
† Aviso preliminar sobre mamiferos mesozoicos, Rev. Mus. La Plata, 1898.

In the "Suplemento," p. 12, he says:

"*Polyacrodon ligatus* Roth p. 384, corresponds with *Didolodus multicuspis* Ameghino, 1897.

Megalacrodon prolixus Roth p. 384, corresponds with *Polyacrodon lanciformis*, Roth p. 383, and *Lamdaconus suinus*, Amegh. 1897."

I now beg to compare Fig. 1, which represents *Didolodus multicuspis*, with Fig. 2, which represents the upper molar, on which my *Polyacrodon ligatus* is founded. While the latter with its very low crown in the form of cones reminds one very much of the Marsupials, the former shows the cones in *Didolodus* already as characteristic features of the Ungulates.



Nevertheless they are said by Ameghino to belong not only to the same genus, but to the same species.

In Fig. 3 I have reproduced *Lamdaconus suinus*, and in Fig. 4*a* and *b* *Megalacrodon prolixus*. The molars of the latter show an astonishing likeness to those of *Didelphys*, while the tooth of *Lamdaconus* exhibits clearly the shape of the Patagonian type of Ungulates. These two animals cannot even belong in the same family.

Any further discussion seems to be unnecessary.

ART. XXVI.—*On a large slab of Uintacrinus from Kansas;* by C. E. BEECHER. With Plates III and IV.

A LARGE slab of limestone preserving on its surface numerous specimens of *Uintacrinus socialis* Grinnell has recently been placed in the exhibition series of the Yale University Museum. This slab is of especial interest on account of its size and for the perfection of the crinoids represented. Bather* has so ably described this species that nothing of consequence can be added regarding the details of structure and probable habits. The present notice, therefore, will necessarily be restricted to minor features.

The first specimens of *Uintacrinus* were collected by Professor Marsh in 1870, from the Cretaceous of the Uintah Mountains, Utah. Later, in 1876, better examples were obtained in western Kansas by Dr. S. W. Williston and by Professor B. F. Mudge for the Yale Museum, which now contains collections of this crinoid from Trego, Gore, Logan, and Wallace Counties, Kansas. Notwithstanding this considerable geographic range, the horizon appears to be nearly constant at about the middle of the Niobrara Chalk.

The specimens are uniformly on the underside of thin lenticular plates of a limestone that in itself is an encrinital rock composed of dissociated crinoid elements. The lenses of limestone seldom have a maximum thickness of an inch. Usually the calyces of *Uintacrinus* are almost completely flattened, but occasionally, as in the slab here described, they stand out in considerable relief, though in none is the normal fullness preserved.

The slab represented on Plate III measures six feet, seven inches, in length (2 meters) by four feet, six and one-half inches in breadth (1^{m} 38^{cm}) and, after making allowance for irregularities in outline, it contains about twenty-seven square feet of surface ($25{,}800^{sq\ cm}$). In this area are the calyces of two hundred and twenty individuals of *Uintacrinus socialis*. The diameter of a calyx of average size, in a somewhat flattened condition, is about 60^{mm}. Occasionally a specimen measures 70^{mm} across, and apparently this is nearly the maximum size attained by the species. The smallest specimens are not more than 20^{mm} in diameter. The arm-branches can seldom be traced more than 10^{cm} from the calyx, though separate ones extend at least five times this distance over the surface.

* On Uintacrinus: a Morphological Study. By F. A. Bather, M.A. Proceedings of the Zoological Society of London, vol. 1895, pp. 974–1004, pls. liv–lvi, 1896.

Most of the specimens are lying on the side with the arms extended ventrally in a plumose manner. A considerable number, however, present the basal aspect of the calyx, and in this position the arm-branches belonging to a particular individual can rarely be observed, since they seem to penetrate below the surface of the slab and lie in another plane. It will be seen that the calyces lying on their sides point in all directions in the plane of the slab, though a considerable number have their arm-branches extended toward the upper edge of the slab as it now stands. This could indicate at the most but an extremely gentle current, and the presence of several small oysters (*Ostrea larva* Lam.) tends to show that the water was of moderate depth.

Two slightly diverging grooves in the surface of the slab at the right, below the middle, suggest the mold of an object like a Baculite, but as no vestige of shell is preserved, it may be an accidental feature.

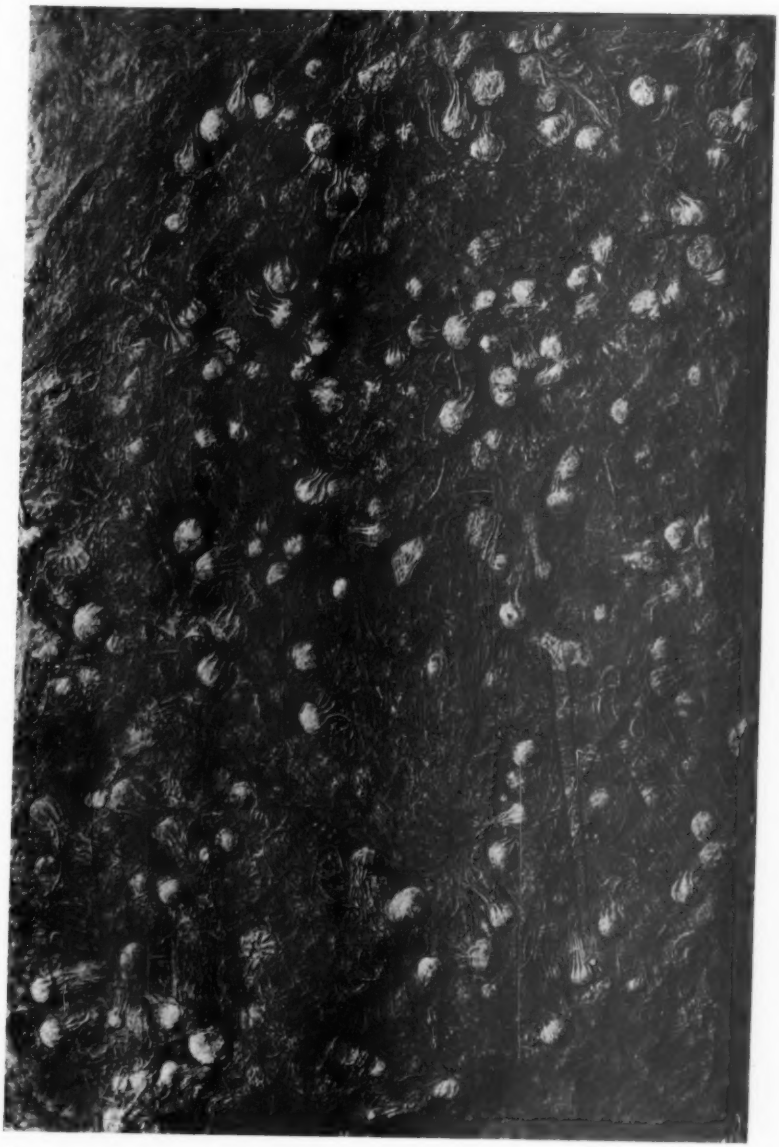
Nearly all the specimens of *Uintacrinus*, as well as the limestone layer containing them, are of a light buff color, while the slight coating of shaly matter is also light in hue, sometimes of a bluish tint, so that the contrast between the fossils and the matrix is not strongly marked. This defect has been obviated by painting the entire slab with a mixture of gum-water and ivory black, which penetrated and adhered to the shaly and weathered surface of the limestone, but was easily washed from the calyces and arm-branches of the crinoids. This treatment has rendered the slab an object of great beauty, with its medusæ-form crinoids and the delicate tracery of the arm-branches against the dark background.

Yale University Museum, New Haven, Conn., February 10, 1900.

EXPLANATION OF PLATES.

PLATE III.—Slab of *Uintacrinus socialis* Grinnell, containing two hundred and twenty individuals. Size 6 ft. 7 in. (2^m) by 4 ft. 6½ in. (1^m 38^{cm}). Niobrara Chalk. Near Elkader, Logan County, Kansas. Presented to Yale University Museum by Professor O. C. Marsh. Collected by H. T. Martin.

PLATE IV.—A portion of the same slab on a larger scale.



UINTACRINUS.

UINTACRINUS.

ART. XXVII.—*Granodiorite and other intermediate rocks;* by WALDEMAR LINDGREN.

Introduction.—Along the great mountain chain which follows the Pacific Coast of America from Cape Horn to Alaska the intrusive rocks and the phenomena accompanying them are displayed upon a scale hardly rivaled elsewhere. Moreover, these intrusions have taken place in comparatively recent times, during Jurassic, Cretaceous and even Tertiary times. The result was the formation or the accentuation of the great ranges now overlooking the Pacific Ocean. The uplift which accompanied the displacing intrusion of enormous masses of magma, was followed by a period of erosion of scarcely appreciated magnitude. This erosion brought to light the deeply buried, intruded granular rocks as great, irregular bodies, *batholiths*, sometimes continuous for hundreds of miles. Before these remarkable relations had been elucidated, the granular rocks of the Pacific Coast were often regarded as Archean; and a close scrutiny of supposedly older areas brings almost yearly additions to the Mesozoic and Tertiary batholiths.

Looking over the results thus far obtained by investigations of these rocks, one cannot fail to note the prevalence of rocks occupying intermediate places between granite and quartz-diorite. The latter are fairly common; the true granites are relatively rare; most common appears an intermediate rock in which the soda-lime feldspars predominate over the orthoclase, and in which the silica varies from 60 to 70 per cent.

Granodiorite, origin of name.—Soon after the beginning of the geological mapping of the Sierra Nevada in California in 1886, it became apparent that the rocks of that region which had previously been referred to as granite were, to a large extent, of intermediate character and could properly be referred neither to the granites, nor to the quartz-diorites. Besides these intermediate rocks, quartz-diorites, diorites, and gabbros were recognized. The prevailing intermediate rock from different parts of the Sierra Nevada was studied by the geologists then working there (G. F. Becker, H. W. Turner, and W. Lindgren) and was found to have a fairly constant character, consisting of a medium to coarse-grained aggregate of quartz, oligoclase or andesine, orthoclase, biotite, hornblende and various accessory constituents, among which titanite was most prominent.

A series of separations by the Thoulet solution were made by the writer of rocks from various points of the Sierra Nevada, partly from the foothills, partly from the Yosemite Valley, and partly from the eastern slope of the Sierra, in the State of

Nevada. The series also included a variety carrying large orthoclase crystals, and extensively developed in Tuolumne County. The result showed that all these rocks were characterized by about the same amount of quartz and that in all of them the soda-lime feldspar (andesine or oligoclase) greatly predominated over the alkali feldspars, both always being present.

A great number of slides had been examined, but at that time (in 1891) the analytical data were less complete than might have been desired. The first analysis considered as representing the composition of granodiorite was the one published by Mr. Clarence King in the volumes of the "Exploration of the 40th Parallel," the locality being El Capitan, Yosemite Valley. This analysis runs as follows:

SiO_2	66·40
Al_2O_3	17·13
FeO	3·77
MnO	·30
CaO	4·05
MgO	·97
K_2O	2·08
Na_2O	4·49
Ignition	1·03
	100·22

For the rock described above the name of *granodiorite* was proposed, the term being suggested by Mr. G. F. Becker. The name was intended to cover intermediate acid rocks which were more closely related to a quartz-diorite than to a granite, but was not proposed as a synonym for quartz-mica-diorite.

Further definitions.—In the text to the older folios of the gold belt the term granodiorite is defined as follows (Sacramento Folio, No. 5, 1894): It should be remembered that these brief descriptions are chiefly intended for the non-technical reader.

"*Granodiorite* (quartz-mica-diorite).—A granular intrusive rock having the habitus of granite and carrying feldspar, quartz, biotite, and hornblende. The soda-lime feldspars are usually considerably and to a variable extent in excess of the alkali feldspars. This granitic rock might be called quartz-mica-diorite, but this term, besides being awkward, does not sufficiently suggest its close relationship with granite; it has, therefore, been decided to name it *granodiorite*.

In the later folios (Truckee No. 39, 1897) the definition is slightly altered in form and reads as follows:

"*Granodiorite.*—A granular intrusive rock having the habitus of granite and carrying feldspar, quartz, biotite and

hornblende. The soda-lime feldspars are usually considerably and to a variable extent in excess of the alkali feldspar. This granitoid rock occupies a position intermediate between a granite and a quartz-diorite, and is in fact closely related to the latter. The large areas occupied by it and the constancy of the type justify the special name."

In 1893 I attempted to limit the rocks from a chemical point of view.* On account of the few analyses available this first attempt could not be as precise as the later definitions, but requires only slight correction. The statement is as follows: "A light gray granitic rock occupies the larger part of the area of the map . . . The rock is in general identical with the gray so-called granite that occupies such large areas in the Sierra Nevada and which probably extends through Southern California far down into the peninsula of Lower California. The rock consists in typical development of feldspar, quartz, biotite and hornblende with medium-grained, hypidiomorphic structure. The soda-lime feldspars are usually considerably and to a variable extent in excess of the alkali feldspars. The silica varies between 60 and 73 per cent; the amount of lime is variable but it rarely exceeds, while it usually falls somewhat short of, the sum of the alkalies. While in some varieties that cannot be distinguished from the others in the field there is more potash than soda, a frequently occurring relation is 2 per cent K_2O to 4 per cent Na_2O. It will be seen that the rock very closely approaches some quartz-mica-diorites and often might be indicated by that name. This term, however, besides being clumsy does not sufficiently express its close relationship to granite, brought out by its frequently high percentage of silica and low percentage of lime, by its variable percentage of alkali feldspar, and by the muscovite sometimes occurring in it."

The last part of this sentence refers to a facies from Rocklin, Placer County and other places which probably should not be included in the granodiorites.

In a report on the veins of Grass Valley and Nevada City, Cal.,† the following definition is given:

"Under the name *granodiorite* are included coarsely granular rocks, intruded and consolidated at considerable depths below the surface, having a normal granitic (eu-granitic) structure, and a mineralogical composition of quartz, soda-lime feldspars, orthoclase, hornblende, and nearly always biotite. Titanite and magnetite are always present as accessory constituents. This rock, which in the Sierra Nevada occurs in enormous areas, forms an intermediate group between the quartz-mica-diorites and the granites, being, however, more

* This Journal, lxvi, 201. The Auriferous Veins of Meadow Lake, Cal.
† 17th Ann. Rept., 1896, U. S. G. S., Part II, p. 35.

closely allied to the quartz-mica-diorite than to the granite. Comparison of numerous analyses from various parts of the Sierra Nevada shows that the chemical composition varies between that of a quartz-mica-diorite and a quartz-monzonite (adamellite, banatite, Brögger). Its geological occurrence and in general entirely similar habit preclude the possibility of dividing it into subgroups.

The rock is very characteristic and cannot easily be mistaken. The feldspars are generally white; the quartz is not very conspicuous and does not occur in large grains, as in some true granites of the High Sierra; the hornblende is dark-green, often in long, rough prisms; the biotite is of the usual dark-brown color. The general effect is a light-grayish color."

The following table is also quoted from the same place:

LIMITS OF VARIATION AND AVERAGE COMPOSITION OF GRANODIORITE.

	Limits of variation. Per cent.	Average composition. Per cent.
SiO_2	59 to 68½	65·
Al_2O_3	14 to 17	16·
Fe_2O_3	1½ to 2¼	1·50
FeO	1½ to 4½	3·
CaO	3 to 6½	5·
MgO	1 to 2½	2·
K_2O	1 to 3½	2·25
Na_2O	2½ to 4½	3·50
Remainder	------	1·75
		100·

In 1897* in a paper on the granitic rocks of the Pyramid Peak Folio, I characterized the granodiorite of the High Sierra as follows: Comparing the analytical and microscopical results with the field notes, it is clear that the granodiorite, as it appears in the High Sierra, is a rock of well-defined and fairly constant composition, structure and appearance. It is neither a normal diorite, nor is it a granite; it is clearly an *intermediate* type, occupying a place between normal quartz-mica-diorite and quartz-monzonite (Brögger).† All transitions toward

* This Journal, vol. iii, 1897, p. 312.

† Though it is often difficult in practice to separate the normal quartz-mica-diorite from the granodiorite, it would seem suitable to restrict granodiorite to the following limits:

SiO_2	59–69 per cent.
Al_2O_3	14–17 "
Fe_2O_3	1½–2¼ "
FeO	1½–4½ "
CaO	3–6½ "
MgO	1–2½ "
K_2O	1–3½ "
Na_2O	2½–4½ "

diorite and, more rarely, toward granite, may be found, but they are local and do not cover large areas, while the normal granodiorite is the prevailing rock of the Sierras. Comparing the type here described with the granodiorites of the many smaller areas enclosed in the slates on the western flank of the range, it can be stated that the latter as a rule approach more closely to the quartz-diorites, the percentage of lime being higher and the percentage of potash more often smaller than equal to that of soda. A few of these smaller granitic areas could, in fact, almost as well be indicated as quartz-mica-diorites. In the general habit, however, in the percentage of quartz, hornblende, and biotite, and in the constant presence of titanite, they are entirely similar to the granodiorites of the High Sierra. Microcline, not common in the granodiorites of the foothill region, occurs abundantly in those of the High Sierra.

A. Table of Complete Analyses.

	Granodiorite.					
	I.	II.	III.	IV.	V.	VI.
SiO_2	65·54	66·65	63·85	67·45	66·40	59·48
TiO_2	·39	·38	·58	·58	----	·93
Al_2O_3	16·52	16·15	15·84	15·51	17·13	17·25
Fe_2O_3	1·40	1·52	1·91	1·76	----	2·15
FeO	2·49	2·36	2·75	2·21	3·77	4·06
MnO	·06	·10	·07	----	----	·11
CaO	4·88	4·53	4·76	3·60	4·05	6·50
SrO	----	tr.	tr.	----	----	tr.
BaO	----	·07	·06	----	----	·09
MgO	2·52	1·74	2·07	1·10	·97	2·67
K_2O	1·95	2·65	3·08	3·66	2·08	2·27
Na_2O	4·09	3·40	3·29	3·47	4·49	3.53
Li_2O	----	tr.	tr.	----	----	tr.
H_2O below 100°C.	----	·18	·28	·14	----	·09
H_2O above 100°C.	·59	·72	1·65	·63	1·03	·71
P_2O_5	·18	·10	·13	·12	----	·33
	100·73	100·55	100·32	100·23	100·22	100·17

I. Lincoln, Placer Co., Sacramento Folio, W. F. Hillebrand analyst.
II. Nevada City, Nevada Co., Smartsville Folio, W. F. Hillebrand analyst.
III. Grass Valley, Nevada Co., Smartsville Folio, W. F. Hillebrand analyst.
IV. 103 Pyr. Pk., Silver Lake, Pyramid Pk. Folio, Geo. Steiger analyst.
V. El Capitan, Yosemite, Cl. King.
VI. 398 Placer Co., Donner Pass, Truckee Folio, W. F. Hillebrand analyst.

The following of the rocks in table B belong to smaller areas enclosed in metamorphic rocks: IV, V, VII, VIII, IX, X. The following numbers represent the great areas in the higher part of the Sierra Nevada: I, II, III, VI, XI, XII, XIII, XIV, XV, XVI, XVII.

B. Table of Partial Analyses of Granodiorites.

	I	II	III	IV	V	VI	VII	VIII	IX
SiO_2	59·48	63·54	62 17	....	....	....	....	65·54	63·85
CaO	6·50	6·11	5·80	5·64	5·64	5·41	5·37	4·88	4·76
K_2O	2·27	1 91	2·23	1·18	1·18	1·82	1·60	1·95	3·08
Na_2O	3·51	2 97	2·86	3·74	3·74	3 15	3·81	4·09	3·29

	X	XI	XII	XIII	XIV	XV	XVI	XVII
SiO_2	66·65	65·88	67·14	66·40	68·13	67·45	68·32	69·85
CaO	4 53	4·11	4·07	4·05	3·51	3·60	3·21	3 08
K_2O	2·65	2·88	2·70	2·08	3·58	3·66	3·37	2·28
Na_2O	3 40	2 41	3·09	4·49	3·13	3 47	2·51	4 13

Localities of Specimens in Table B.

I. 398 Placer Co., Donner Pass, Truckee Folio, Geo. Steiger analyst.
II. 225 Nevada Co., 2 miles S. of Faucherie Lake, Colfax Folio, Geo. Steiger analyst
III. 221 Nevada Co., 1 mile S. W. of Faucherie Lake, Colfax Folio, Geo. Steiger analyst.
IV. 338 El Dorado Co., 1¼ mi. S. of Fairplay, Placerville Folio, W. H. Melville analyst.
V. 293 Placer Co., Penryn, Sacramento Folio. W. H. Melville analyst.
VI. 305 El Dorado Co. Point between Soldier Creek and South Fork of American River, Placerville Folio. W. H. Melville analyst.
VII. 104 El Dorado Co White Rock Cr., Placerville, Placerville Folio, W. H. Melville analyst.
VIII. Lincoln, Placer Co., Sacramento Folio, W. F. Hillebrand analyst.
IX. Nevada City, Nevada Co., Smartsville Folio. W. F. Hillebrand analyst.
X. Grass Valley, Nevada Co., Smartsville Folio, W. F. Hillebrand analyst.
XI. 177 Pyramid Pk., Meeks Creek, Lake Tahoe, Truckee Folio, Geo. Steiger analyst.
XII. 86 Pyramid Pk., Rockbound Lake, Truckee Folio, Geo. Steiger analyst.
XIII. El Capitan, Yosemite, Cl. King.
XIV. 69 Pyramid Pk., 1½ mi. S. of Rubicon Point, Truckee Folio, Geo. Steiger analyst.
XV. 103 Pyramid Pk., Silver Lake, Pyramid Pk. Folio, Geo. Steiger analyst.
XVI. 120 Pyramid Pk., Big Mud Lake, Pyramid Pk. Folio, Geo. Steiger analyst.
XVII. 231 Nevada Co., Rattlesnake Cr., 2 m. N. E. of Cisco, Truckee Folio, Geo. Steiger analyst.

Characteristic features and limits of granodiorite.—Under the term granodiorite are included light-colored granular rocks, composed of quartz, oligoclase or andesine, orthoclase, biotite or hornblende or both, titanite, magnetite, apatite and zircon. The average grain ranges from 1 to 4^{mm}, but certain of the minerals sometimes considerably exceed this. Thus the hornblende prisms are often 10^{mm} long and those of orthoclase may be still larger. The fresh outcrops are brilliantly grayish white, and even when decomposed the amount of ferric oxide set free is rarely sufficient to impart a red color to the rock.

In thin section the structure is typically hypidiomorphic. The biotite and hornblende are sometimes, the soda-lime felds-

spars nearly always partly idiomorphic; these minerals are usually cemented by a later consolidated mass of orthoclase and quartz. The orthoclase may, in types relatively rich in K_2O, assume the form of microcline; albite and perthitic growths are ordinarily absent, but the latter have been noted in small amounts. The soda-lime feldspar generally ranges from Ab_7An_3 to Ab_2An_1; and is always either a basic oligoclase or an andesine; acid oligoclase or varieties containing more lime than andesine are absent. The biotite is a dark brown normal variety with small but distinct angle between the optic axes. The hornblende is green or brownish-green with a maximum extinction of 18°–20°. Pyroxene (augite) is known as kernels in hornblende, though the latter is certainly not of secondary origin. It is by no means impossible that granodiorites with a notable amount of pyroxene may be found, but they certainly are not very common and represent no widely spread type. In the normal types both biotite and hornblende are usually present. But either one may occasionally be sparingly represented or even absent. Titanite is an always present constituent of the rock. Magnetite is only present in small quantities.

C. Table of Mineralogical Composition of Granodiorite.

Numbers correspond to Table A.

	II	III	IV
Potassium feldspar	15·	18·	17·75
Sodium feldspar	29·[a]	28·[a']	29·41[a'']
Calcium feldspar	15·[b]	12·10[b']	11·91[b'']
Biotite	16·		12·79
Hornblende		16·60	
Quartz	22·	20·80	25·71
Apatite	·24	·30	·30
Magnetite	1·50	1·50	·84
Titanite	1·	1·40	1·40
Total	99·74	98·70	100·11

$a + b = 44\cdot = Ab_2An_1$, with 34 per cent An.
$a_I + b_I = 40\cdot1 = Ab_7An_3$, with 30 per cent An.
$a_{II} + b_{II} = 41\cdot32 = Ab_7An_3$, with 29 per cent An.

The chemical composition of the granodiorites in the Sierra Nevada is characterized by a percentage of silica neither very high nor very low, ranging from 59 to 69 per cent. The iron and magnesia are relatively low, the lime on the contrary ranging between 3 per cent and 6·50 per cent, though the latter limit is rarely reached. The sum of the alkalies ranges from 4·92 to 7·13 and thus may notably exceed the lime, but never fall short of it more than one per cent. As to the relation between K_2O and Na_2O the latter is apt to predominate, rang-

ing from 2·50 per cent to 4½ per cent. K_2O varies in the analyses from 1·18 per cent to 3·66 per cent and may equal or even slightly exceed Na_2O, especially in the more acidic types from the High Sierra. Where the percentage goes below 1· the rocks should certainly be classed as quartz diorites.

The above tables give complete analyses of six granodiorites, partial analyses of seventeen rocks, and the calculated mineralogical composition of three rocks.

Regarding VI in Table A and I in Table B of incomplete analyses, it should be stated that, owing to the low percentage of silica and large amount of iron and magnesium, it stands close to the limit and may be considered as a quartz-diorite or a granodiorite. That it has been included in this table is due to the fact that these changes from the composition of a normal granodiorite have only been effected by the addition of hornblende without much altering the proportion and composition of the feldspars.

Another somewhat doubtful rock is XVI in the second table, which has a high percentage of K_2O coupled with an unusually small amount of Na_2O, and it is probable that it represents a local facies of the prevailing rock. Its composition would probably place the rock close to the quartz-monzonites.

The last tables give the calculated mineralogical composition of three representative rocks. For the determination of the potash feldspar all of the K_2O except the quantity needed for biotite has been used. Similarly all of the Na_2O, deducting a small amount for the hornblende, has been calculated as albite. All of the albite has been added to the anorthite as soda-lime feldspar. The potash-feldspar undoubtedly contains some soda but that it is only a small amount, is shown by the fact that microperthite, albite and anorthoclase are not generally present and, furthermore, because the calculated soda-lime feldspar closely agrees in composition with that inferred from optical measurements.

Regarding the "average composition" quoted above from my report on Nevada City and Grass Valley, it should be borne in mind that most of the analyses available in 1896 were made of the more basic type of granodiorite, so that the lime is a little higher and potash lower than would be the case if the large areas of the somewhat more acidic type of the High Sierra were considered. It is clear besides that it will be very difficult to obtain such an average, for not only the analyses but the weight in proportion to the rock masses should be considered.

I have no radical change to propose in the chemical limits of the rock given in the paper on the Pyramid Peak region, referred to on page 272. Only, as to the percentage of silica it

should be stated that the granodiorites *of the Sierra Nevada* vary between 59 and 69 per cent; but just as granites and quartz-diorites include rocks with up to 74 per cent or even more of silica, so should the family of the granodiorites include similar acidic types, though they do not appear to be of very common occurrence.

In regard to the lime it may be said that the upper limit (6·50 per cent) is rarely reached and when at the same time the potash approaches 1 per cent the rock should rather be classed as a quartz-diorite. When the percentage of silica falls below 59 the percentage of orthoclase is usually also lowered to such a degree that the rocks become diorites.

With high silica in rocks which otherwise correspond exactly to the composition of a granodiorite the lime is apt to fall low and may in rocks closely related to monzonites even descend to 2·80 per cent.

The truly characteristic features of the granodiorites is that the soda-lime feldspar, which always is a calcareous oligoclase or an andesine, is *at least* equal to double the amount of the alkali feldspar. The latter may be taken to vary from 8 per cent to 20 per cent. Below the lower limit the rock becomes a quartz-diorite: above the upper a quartz-monzonite.

Distribution of types.—As with all other classes of rocks, granodiorite presents somewhat varying types in different localities. Many of the intrusive areas in the foothill region and on the middle slopes of the Sierra Nevada are associated with normal diorites, quartz-diorites and gabbros. As a consequence of the generally more basic character of the magma, the granodiorite of the foothills shows a basic type with relatively higher percentage of lime and lower of potash (see IV, V, VI, VII). In the great granitic areas of the Sierra the general type of the magma is more acidic, hence the granodiorite tends more towards an acidic type without exceeding the limits of the family. However, extensive masses of granodiorites of the more basic type (as well as diorites) exist on the quadrangles of Truckee and Colfax, in the High Sierra. These two types resemble each other so much that their separation in the field appears entirely impracticable. From a cursory examination it appears probable that much of the granitic masses of Southern California belong to the granodiorites. A large part of those of the peninsular range of Lower California are certainly granodiorites, as I have shown by microscopical examination and separation by Thoulet Solution.*

Relation to allied rocks.—In 1895 Prof. W. C. Brögger established the new family of the monzonites,† rocks intermediate in composition between granite and diorite.

* Proc. Cal. Acad. Sci., 2nd Ser., vol. i, part 2, p. 6, 1888.

† Die Eruptions folge der triadischen Eruptivgesteinen bei Predazzo in Südtyrol. Kristiania, 1895, p. 19.

In view of this it may be profitable to inquire into the limits assigned to this rock and to its relation to granodiorite.

In order to make accurate comparisons it is necessary to have accurately defined standards; the lack of these is very much felt in attempts at rock classification. "Granite" is a term concerning the petrographic meaning of which there can be little doubt. True, certain geologists have fallen into the habit of using this name as a synonym for "granular rocks," but this is a practice which should not be encouraged.*

A granite means petrographically a granular rock composed of quartz and alkali feldspar with a micaceous mineral or hornblende. There are, however, but few rocks which exactly correspond to this type, more or less soda-lime feldspar being ordinarily present; it may be referred to as an *extreme* type from which the rock can vary only one way, and the majority of our granites are therefore more or less pronouncedly intermediate between granite and diorite.

Diorite is ordinarily defined (Rosenbusch) as a granular rock composed of soda-lime feldspar, and biotite, pyroxene, or amphibole singly or severally; with added quartz the family of the quartz-diorites is formed. While this is the most generally accepted definition, some petrographers deny admission into this family to the varieties carrying pyroxene. It will be apparent at a glance that unless the very wide term soda-lime feldspar is qualified, this family would include diabases and gabbros as well, and to make separate families of the latter is to sacrifice logical classification. What is really done for practical purposes is expressed by Brögger as follows:† "Die einzige moegliche Trennung wird hier nach meiner ansicht diejenige sein, den Begriff Diorit für mittelsaure Tiefengesteine, den Begriff Gabbro für basische Tiefengesteine der Plagioklasreihe, den Namen Diabas für entsprechende hypabyssische Gesteine und für palaiotype‡ Ergussteine zu reserviren." Assenting to this limitation, it is still true that diorite and quartz-diorite, owing to the variation of soda-lime feldspars, is a less precise term than granite.

It became apparent to Prof. Brögger, as it did to the Californian geologists, that the terms granite, diorite and quartz-diorite were no longer sufficient for present purposes, and this necessity of special names for transition types or intermediate rocks is often expressed in his writings. The result was the

* "Granolites" has been proposed as a convenient word, embracing all rocks of granular structure, and though open to criticism in some respects certainly offers some advantages. See H. W. Turner, Journal of Geology, 1899, p. 141.

† l. c. p. 17.

‡ American petrographers will probably object to this limiting of diabase; the Columbia (Miocene) lava formation, for example, contains abundant instances of diabase flows.

proposal to establish the new family of the monzonites intermediate between the syenites and the diorites, and that of the quartz-monzonites intermediate between the granites and the quartz-diorites. The kernel of the definition of these rocks is contained in the following words:* "Das wirklich characterische bei diesen Gesteinen, ist dass sie in der Regel Orthoklas und Plagioklas ungefähr gleich reichlich oder jedenfalls beide reichlich führen." On the same page we read "Die Monzonite characterisiren sich dadurch dass sie weder zu den Orthoklas-Gesteinen noch zu den Plagioklas-Gesteinen, sondern zu einer Uebergangsgruppe zwischen beiden gehören, sie sind eben: Orthoklas-Plagioklas-Gesteine." In the same place Prof. Brögger states that in his opinion, in order to apply the name diorite, the soda-lime feldspars must strongly predominate; in granite, on the other hand, the alkali feldspars must strongly predominate or (see footnote) the plagioclase must be so acid that the rock is very poor in lime.

In the above definition there is no special limit assigned to the soda-lime feldspars, so that the permissible variation becomes rather large. It must be apparent, however, that the author intended the rock in its most typical development to be placed exactly half way between the granites and the quartz-diorites so far as the feldspars were concerned. This view is corroborated by the fact that of the two calculated analyses given, the first —a monzonite—has 30 per cent orthoclase and 32 per cent soda-lime feldspar (Ab_2An_3) and the second—a quartz-monzonite—(p. 62, l. c.), 35·5 per cent orthoclase and 31·5 per cent Ab_2An_3.

Thus the term quartz-monzonite becomes a *central* type embracing a series of rocks on each side of the definition. Just how far Brögger intended to extend these limits is not clearly stated.

There is undoubtedly ample justification for the introduction of the term quartz-monzonite as defined by Brögger, but reasonable limits should be assigned to it. It would manifestly be incorrect to define a family as having approximately equal amounts of orthoclase and soda-lime feldspars and then include in it rocks having three or four times as much of one as of the other. The definition of granodiorite would give it, say from 8 per cent to 20 per cent orthoclase. In the quartz-monzonites I would give this mineral a range from 20 per cent to 40 per cent, all in an assumed total of 60 per cent feldspars. The rocks containing more than 40 per cent orthoclase would then be classed as granites, there being scarcely room for another family between the quartz-monzonites and the granites.

*l. c. p. 21.

In this manner the former family becomes quite extensive and certainly includes wider limits than does granodiorite. In a postscript to his discussion of the rocks from Monzoni (p. 182) Prof. Brögger devotes a few paragraphs to granodiorites, stating that according to the analysis (No. I in Table A) the rock clearly belongs to the quartz-diorites or rather to the small group between the diorites and the quartz-diorites. He finally concludes that granodiorite is not used in the same sense as quartz-monzonite but rather as a synonym for tonalite. This view is clearly due to the fact that Brögger only recognizes one intermediate group, placing it exactly in the middle between the granites and the quartz-diorites. The above discussion has sufficiently set forth that granodiorite is not a synonym for quartz-mica-diorite or tonalite, which is a typical rock of that kind, except in this sense that many petrographers have formerly used the term quartz-mica-diorite, in absence of others, for rocks comparatively rich in orthoclase.

It has been proposed* by Mr. Turner to class rocks of the composition of IV (and consequently also rocks like III) in Table A as quartz-monzonites. This can only be done by disregarding the definition given by Prof. Brögger of this latter rock. No. IV contains 17·75 per cent orthoclase and 41·40 per cent soda-lime feldspars; this is clearly a rock in which the latter feldspars *greatly predominate* and not a rock with approximately equal quantities of the two feldspars.

Taking an example to the point, there are in Idaho large areas of a granular rock having the following composition:

SiO_2	68·48
Al_2O_3	15·01
FeO	2·90
CaO	2·60
MgO	1·21
K_2O	4·25
Na_2O	3·22
Rest.	2·33
	100·00

From the data obtained by microscopic examination, this rock may be calculated as follows:

Alkali feldspar	21·
Oligoclase	34·
Biotite	13·
Quartz	29·
Accessories	3.
	100·

* H. W. Turner, The Granitic Rocks of the Sierra Nevada. Journal of Geology, 1899, p. 141.

Owing to the low percentage of CaO and large amount of K_2O this rock would fall outside of the limits of granodiorite and may approximately be referred to as a quartz-monzonite. This rock has all the appearance of a granite, and from field examination was supposed to belong to that family.

In the critical examination of proposed rock types the definition is clearly first to be considered, secondarily the analyses. Turning now to the analyses of quartz-monzonites given by Brögger, a perusal will convince that representatives of his definition are few in number. The group with less silica or the banatites is represented by five analyses, four of which easily fall within the limits of the granodiorites. The mean of the analyses is as follows:

	Adamellite.	Banatite.
SiO_2	69·27	64·39
Al_2O_3	13·47	15·90
Fe_2O_3	4·82	4·69
CaO	3·25	4·15
MgO	1·02	1·93
K_2O	3·85	3·52
Na_2O	3·29	3·58

By reason of the high potash the adamellite of this average falls outside of the granodiorites though it hardly corresponds to Brögger's definition. The banatite, on the other hand, would be identical with some types of granodiorite if the analyses were actually representative. Brögger's average of banatite is thus not only on one side of his definition but very much so, inasmuch as the soda-lime feldspar will be equal to about three times the quantity of orthoclase, provided that the mineral composition of the rocks is similar to that of a granodiorite.

I think in fact that it will be difficult to obtain any considerable number of analyses of granular rocks, having the average silica content of 65 per cent and about equal quantities of alkali and soda-lime feldspars. In other words, it does not appear probable that the banatite, which corresponds to Brögger's definition, is a very common and widespread family of rocks.

Granodiorite porphyry.—Minor intrusive masses and dikes, having the composition of granodiorite combined with a porphyritic holocrystalline groundmass, are not uncommon. For these I propose the name granodiorite porphyry, in analogy with granite porphyry and diorite porphyry.

Conclusions.—Granodiorite, a member of the great family of rocks with predominating soda-lime feldspars, is distinguished by a granular texture, grayish color and a mineral

composition of quartz, oligoclase or andesine, orthoclase or microcline, hornblende or biotite (usually both); the accessories being titanite, apatite, magnetite and zircon. The quartz may average 23 per cent, the soda-lime feldspars 44 per cent, the orthoclase (with microcline and albite) 14 per cent, varying from 8 per cent to 20 per cent, the ferro-magnesian silicates 14 per cent. These figures are not claimed to be an exact average, which in the nature of the case is difficult to obtain, but they correspond to a fairly typical rock. The family is proposed to represent a very important and very widespread type of rocks, especially common along the Pacific slopes of the Cordilleran Ranges. This family has been clearly defined; the name has for many years been in use in the folios of the U. S. Geological Survey. It has found rapid and general acceptance by reason of its simple construction and its implied definition. But chiefly and above all it deserves to stand because representing a natural group of rocks.

Washington, D. C., December, 1899.

ART. XXVIII.—*Two new American Meteorites;* by H. L. PRESTON.

Luis Lopez, New Mexico.

THE Luis Lopez siderite is somewhat rectangular in shape and measures $80 \times 130 \times 195^{mm}$ in its greatest diameters; it is the property of Prof. Henry A. Ward of Chicago.

When received by Prof. Ward, it was entire, lacking possibly 40 or 50 grams that had been sawn off one of the prominent protuberances. The actual weight when received was 6,903 grams. The general shape of the mass was quite symmetrical and covered on all sides with large and prominent pittings.

The outer surface was entirely covered, save the small cutting, with a rather lustrous reddish-brown crust. On cutting the mass, numerous troilite nodules ranging in size from 8 to 28^{mm} in diameter were found, some sections containing as many as four nodules of large size. There were numerous straight fissures one millimeter or less in thickness, and from 40 to 70^{mm} in length, which are filled with troilite.

On etching the surface of these sections, the Widmanstätten figures are brought out, sharp and distinct; they are typically octahedral, and composed of broad laminæ, the kamacite bands being from 1 to 3^{mm} in diameter, and up to 41^{mm} in length, in some cases without a break.

There are also numerous small streaks or seams of schreibersite, the longest as far as observed being 8^{mm} and a trifle less than 1^{mm} in width.

The troilite nodules are likewise surrounded by a very narrow band of schreibersite, which presents a strong contrast between the silvery white kamacite bands and the bronze-colored troilite nodules. In some few instances, a black graphitic substance, from 1 to 3^{mm} in width, is seen surrounding the troilite nodules, between the narrow band of schreibersite and the kamacite. The minute hair-like lines commonly called laphamite markings are abundant in the rhomboidal patches known as plessite. These lines are caused by minute alternating layers of kamacite and tænite, plessite, as proved by J. M. Davison, being formed in this way, and not a different nickel-iron alloy as formerly supposed.

This meteorite was found in the early part of 1896 by a Mexican named Gonzales, who was very reticent for a long time about giving its exact locality, supposing he had found indications of a valuable mine. But later Mr. C. T. Brown of Socorro, New Mexico, succeeded in obtaining the mass, and

was informed by the Mexican that he had made further search for more pieces but found none. He had picked this piece up about five miles southwest of Socorro, near the hamlet of Luis Lopez.

In the autumn of 1896, the mass as found passed into the possession of Mr. A. B. Fitch of Magdalena, N. M., who retained it in his possession until June, 1899, when it was purchased by Prof. Ward.

From its near proximity to the above hamlet, we will designate this siderite as the *Luis Lopez meteorite*, Socorro County, New Mexico.

An analysis by Mariner and Hoskins of Chicago gave

Fe	91·312
Ni	8·170
Co	·160
Si	trace
P	·333
S	·013
C	·012
	100·

Specific gravity .... 7·7.

As this portion of New Mexico has been somewhat prolific in new meteorites within the past few years, it is perhaps advisable to note the relation of this find to five others, making a total of six siderites found in a parallelogram of about three hundred miles by ninety.

1st. We have the *Costilla Peak* of about 35 kilograms, found in August, 1881, on the north slope of Costillo Peak about 210 miles N.N.E. of Socorro, described by R. C. Hills.

2d. *Glorieta Mountain.* Three masses of 24·26, 53·38 and 67·12 kilograms, that were apparently portions of the same mass originally, and several smaller pieces found in May, 1884, on Glorieta Mountain, 120 miles N.N.E. of Socorro, described by Geo. F. Kunz.

3d. *El Capitan*, of about 28 kilograms, found in 1893 on the north slope of El Capitan Mountain, 90 miles S.E. of Socorro, described by E. E. Howell.

4th. *Sacramento Mountain.* 237 kilograms, surmised to have fallen in 1876 and found on the eastern slope of the Sacramento Mountains 120 miles S.E. of Socorro, described by Warren M. Foote.

5th. The *Oscuro Mountain*, of about 6 kilograms, found in three pieces Dec. 10th, 1892, in the eastern foot hills of the Oscuro Mountains, about 35 miles S.E. of Socorro, described by R. C. Hills.

6th. The present siderite, *Luis Lopez*, 6·9 kilograms, found in 1896, five miles S.W. of Socorro.

It is absolutely certain that these six finds represent six distinct falls of meteorites, as proved first by the analyses:

	Fe	Ni
Costilla	91·65	7·71
Glorieta	87·93	11·15
El Capitan	90·51	8·40
Sacramento Mts.	91·39	7·86
Oscuro	90·79	7·66
Luis Lopez	91·31	8·17

Secondly, the crystalline structure, as shown by the Widmanstätten figures, is so entirely different that it would be impossible to confound either one with any other of these finds.

Central Missouri.

The history of this most interesting siderite as to the exact date when found, and the precise locality where found, has been entirely lost.

The weight of the whole was probably about 25 kilograms. An end piece apparently about half the entire mass, weighing 12,360 grams, has been deposited for many years in the Western Reserve Historical Society of Cleveland, Ohio, while the other half was in the collection of the late Prof. Wm. Denton of Wellesley, Mass. Through the Librarian of the Western Reserve Historical Society, Prof. J. P. MacLean, Prof. Ward has obtained a large portion of this piece.

The outer surface of the mass is most beautifully and typically pitted, and of a dark reddish-brown color, with the exception of the prominent ridges, which are of a lustrous dark steel-gray color, resembling graphite, although it does not soil paper when rubbed over it.

On cutting the mass, we found numerous fissures meandering in various directions over the entire surface. A few of the largest are one millimeter in diameter, and are filled in part by a black graphite-like substance, and in part by schreibersite. There are also patches of schreibersite, resembling hieroglyphics, some of them 5 by 25^{mm} in diameter, scattered here and there over the surface. A few prominent troilite nodules are visible on the sections, the largest being 9×15^{mm} in diameter. On etching the iron no figures whatever are brought out, leaving only a minutely pitted light gray surface, which is more or less clouded.

The only history of the finding of this siderite as furnished by Prof. J. P. MacLean from the records of the Western Reserve Historical Society, is as follows:

"This meteorite was found in the fifties in Central Missouri, and after being cut in halves, one-half went to the late Prof. Wm. Denton and the other half was purchased of Mrs. Newcomer (of Cleveland) by the late Judge C. C. Baldwin, and by him presented to the Society."

An analysis of this siderite by Mariner and Hoskins of Chicago gave

Fe	94·734
Ni	4·620
Co	·180
P	·442
S	·015
C	·009
	100·

Specific gravity, 7·5.

The small amount of carbon is probably due to the fact that the portion of the mass used for analysis was free from the black graphite-like veins.

As no more definite locality can be traced as the location in which this iron was found, we will designate for this iron the name, Central Missouri.

Art. XXIX.—*On the Best Form for the Double Achromatic Objectives of Telescopes;** by Wm. Harkness.

When the thicknesses and distances apart of the two component lenses are so small that they can be neglected, the curvatures of the surfaces of these lenses are the only disposable constants for satisfying the equations which determine the properties of a double achromatic objective. As there are four of these surfaces, four conditions can be satisfied. Three of them are always employed in determining the focal length of the objective, its color correction, and the correction for spherical aberration of rays proceeding from an infinitely distant point lying in the optical axis of the telescope. For the disposition of the remaining constant various conditions have been proposed, among which the following may be mentioned because they have secured a prominent place in optical practice:

In 1756 Clairaut† suggested that the interior surfaces of the crown and flint lenses should have the same curvature, in order that they might be cemented together, and that plan has since been almost universally adopted in all spy and binocular glasses. In 1778 Klügel proposed that the crown lens should be made equi-convex, in order to secure with a given thickness of glass the shortest possible focal distance, or, in other words, the greatest possible angular aperture; and in 1810‡ he proposed that the radii of the outer and inner surfaces of the crown lens should be to each other as 1:3, or more exactly as $(2-n):n$, where n is the refractive index of the glass. The method of determining the curves of the objective when the crown is equi-convex was greatly improved by Littrow in 1827§ and since then that construction has been much employed under the name of Littrow's objective. In 1816 Bohnenberger wrote a paper to show that the spherical and achromatic aberrations were best corrected by making the radii of the outer and inner surfaces of the crown lens in the ratio of 2:3, and that construction has also found much favor. Finally, about 1824 or 1825 Fraunhofer introduced a form of objective which is certainly superior to any previously known, but he never gave its theory, and because it is rather more difficult to make and adjust than the forms advocated by Clairaut, Klügel, Littrow and Bohnenberger, it has never been popular with practical opticians.

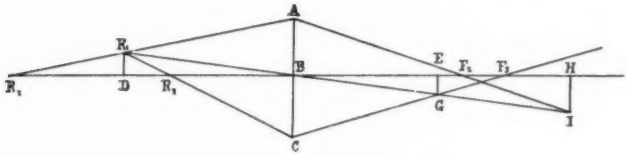
* This paper, in a slightly different form, was read before the Philosophical Society of Washington on October 28, 1893.

† Mem. Paris Acad., 1756, p. 431.

‡ Gilbert's Annalen, 1810, xxxiv, 280.

§ Mem. Roy. Ast. Soc., 1827, vol. iii, pp. 235–255.

The conditions which should be satisfied by a perfect objective are, first, that it shall have a specified focal length; second, that its achromatic aberration shall be corrected, which, strictly speaking, would include the destruction of the secondary spectrum, but that point will not be considered in the present paper; and third, that its spherical aberration shall be corrected, not only for distant objects lying in its optical axis, but for all objects, whether near or remote, situated anywhere within its field of view. It has been surmised that the latter condition was what Fraunhofer aimed at in the object-glasses which he constructed, but I am not aware that the mathematical theory involved in the said condition has ever been formulated, and, therefore, it seems worth while to examine it here.



Referring to the figure, let AC be a thin lens whose optical axis is R_2H, and let F_2 and F_3 be, respectively, the focal points for axial rays proceeding from the radiants R_2 and R_3. Furthermore, let R_1 be an oblique radiant situated on the straight line joining R_2 with A, and let the rays R_1AI and R_1CG proceed from it. The straight line R_1BGI, passing through the optical center of the lens, will be intersected by them at G and I, and consequently images of R_1 will be formed throughout the entire interval between these points. Finally, draw the lines R_1D, EG and HI perpendicular to the optical axis R_2H.

For brevity let

F = Principal focal distance of the lens AC.
y = $AB = AC$ = semi-diameter of the lens AC.
R_1 = Distance DB. F_2 = Distance F_2B.
R_2 = Distance R_2B. F_3 = Distance F_3B.
R_3 = Distance R_3B. ω = The angle $R_1BD = IBH$.

An examination of the figure shows that the oblique spherical aberration arising from the eccentric position of the radiant R_1 is represented by the interval EH between the images at G and I, and in order to destroy it, the point G must be made to coincide with the point I. That will be the case when $BE = BH$, and we have now to inquire what conditions must subsist in order to bring about this equality.

From the figure we have

$$y : F_2 :: BE \tan \omega : F_2 - BE$$

whence,

$$BE = \frac{yF_2}{y + F_2 \tan \omega} \tag{1}$$

and again from the figure

$$y : F_2 :: BH \tan \omega : BH - F_2$$

whence,

$$BH = \frac{yF_2}{y - F_2 \tan \omega} \tag{2}$$

Then, to make $BE = BH$, we equate the right hand members of (1) and (2) and obtain

$$\frac{F_2}{y - F_2 \tan \omega} = \frac{F_3}{y + F_3 \tan \omega} \tag{3}$$

which is the condition for the destruction of the oblique aberration.

If now we suppose the spherical aberration of the lens AC to be perfectly corrected for all objects situated in its axis, whether near or far, and if F_2 and F_3 are the focal points for rays diverging respectively from the radiants R_2 and R_3 then we shall have rigorously, for all points of the lens

$$\begin{aligned} 1/F &= 1/F_2 + 1/R_2 \\ 1/F &= 1/F_3 + 1/R_3 \end{aligned} \tag{4}$$

From the figure

$$R_2 - R_1 : R_2 :: R_1 \tan \omega : y$$

whence,

$$\frac{1}{R_2} = \frac{1}{R_1} - \frac{\tan \omega}{y} \tag{5}$$

and again from the figure

$$R_1 - R_3 : R_3 :: R_1 \tan \omega : y$$

whence,

$$\frac{1}{R_3} = \frac{1}{R_1} + \frac{\tan \omega}{y} \tag{6}$$

By substituting the right hand members of (5) and (6) in (4), we obtain,

$$\frac{1}{F} - \frac{1}{R_1} = \frac{1}{F_2} - \frac{\tan \omega}{y} = \frac{1}{F_3} + \frac{\tan \omega}{y}$$

whence,

$$\frac{F_2}{y - F_2 \tan \omega} = \frac{F_3}{y + F_3 \tan \omega} \tag{7}$$

which is identical with (3); and as the validity of (7) depends only upon the exact fulfillment of the condition expressed by the equations (4), while (3) implies the destruction of the oblique aberration, we conclude that

If in any thin lens the spherical aberration is completely corrected for all objects situated in the axis of the lens, then the oblique aberration will also be completely corrected.

Thus the problem of obtaining equally distinct images in all parts of the field of view is reduced to the problem of making the destruction of the spherical aberration for axial rays independent of the distance of the radiant from the telescope, and we have now to inquire how far that can be done in the case of double achromatic objectives. Fortunately the latter problem is not new, having presented itself to Sir J. F. W. Herschel so long ago as 1821, when he showed that the spherical aberration of an achromatic objective consisting of any number of thin lenses in contact can be expressed in the form

$$\Delta f = \tfrac{1}{2}y^2 (X + YD + ZD^2) \qquad (8)$$

where y is the semi-aperture of the objective, X, Y and Z are functions of the refractive indexes and focal distances of the several lenses, and of the radii of curvature of their first surfaces, and D is the reciprocal of the distance of the object viewed. Of course the refractive indexes are known, and the focal length of the objective together with the achromatic equation determine the focal distances of the several lenses. Consequently equation (8) contains as indeterminates only the radii of curvature of one surface of each lens; and in the case of a double objective, two independent conditions suffice to determine them. Herschel concluded that these conditions should be

$$X = 0 \qquad Y = 0 \qquad (9)$$

because the term depending on D is thus destroyed for all distances of the radiant, and although the term in D^2 still remains, it is usually small enough to be neglected whenever D does not exceed 0·01 of the length of the telescope. He summed up the situation by saying,*

"If these equations be combined, we shall obtain the dimensions of an object-glass free from aberration, both for celestial and terrestrial objects, provided we restrict our views to objects situated in the prolongation of the axis of the telescope."

That proviso is shown by the present paper to be a mistake, but from Herschel's point of view it seemed necessary, because his equations contained no explicit provision for the destruction of the lateral aberration.

* Phil. Trans., 1821, p. 260.

The equations (9) are of the second degree, and consequently give two sets of radii. Herschel preferred that set which gave the flattest curves to the lenses, and it is to be remarked that the resulting objectives resemble those constructed by Fraunhofer so closely as to be practically undistinguishable from them.

In double achromatic objectives of Herschel's form the four disposable constants are employed as follows:

1. To determine the focal length of the objective.
2. To correct the chromatic aberration for rays of some definite wave length.
3. To correct the spherical aberration of central rays proceeding from infinitely distant objects.
4. To correct the spherical aberration of central rays, so far as the first power of the distance is concerned, for all objects, no matter what their distance from the telescope.

From what precedes it is evident that the last condition carries with it the destruction of the lateral spherical aberration up to the locus where the term in D^2 becomes sensible, and as that term is practically indestructible, we conclude that objectives of the Herschel form excel all others consisting of two lenses in contact in being aplanatic throughout the largest possible field of view, and for objects over the greatest possible range of distance. In meridian circles, transit instruments, zenith telescopes, photographic telescopes, and all other instruments where good definition is required over an extensive field, this is of the utmost importance, but for equatorial telescopes it is of less consequence, because their more restricted fields scarcely permit the lateral aberration to become sensible.

Washington, D. C., Feb. 6, 1900.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Passage of Argon through thin Films of India-rubber;* by Lord Rayleigh.—Soon after the discovery of argon it was thought desirable to compare the percolation of the gas through india-rubber with that of nitrogen, and Sir W. Roberts-Austen kindly gave me some advice upon the subject. The proposal was simply to allow atmospheric air to percolate through the rubber film into a vacuum, after the manner of Graham, and then to determine the proportion of argon. It will be remembered that Graham found that the percentage of *oxygen* was raised in this manner from the 21 of the atmosphere to about 40. At the time the experiment fell through, but during the last year I have carried it out with the assistance of Mr. Gordon.

The rubber balloon was first charged with dry boxwood sawdust. This rather troublesome operation was facilitated by so mounting the balloon that with the aid of an air-pump the external pressure could be reduced. When sufficiently distended the balloon was connected with a large Toepler pump, into the vacuous head of which the diffused gases could collect. At intervals they were drawn off in the usual way.

The diffusion was not conducted under ideal conditions. In order to make the most of the time, the apparatus was left at work during the night, so that by the morning the internal pressure had risen to perhaps three inches of mercury. The proportion of oxygen in the gas collected was determined from time to time. It varied from 34 per cent when the vacuum was bad to about 39 per cent when the vacuum was good. On an average it was estimated that the proportion of oxygen would be about 37 per cent of the whole. The total quantity of diffused gas reckoned at atmospheric pressure was about 300^{cc} per twenty-four hours.

On removal from the pump the gas was introduced into an inverted flask standing over alkali, and with addition of oxygen as required was treated with the electrical discharge from a transformer in connection with the public supply of alternating current. In this way the nitrogen was gradually oxidized and absorbed. Towards the close of operations the gas was transferred to a smaller vessel, where it was further sparked until no further contraction occurred, and the lines of nitrogen had disappeared from the spectrum. The excess of oxygen was then removed by phosphorus.

It remains only to record the final figures. The residue, free of oxygen and nitrogen, from 3205^{cc} of diffused gas was 39^{cc}. The most instructive way of stating the result is perhaps to reckon the argon as a percentage, not of the whole, but of the nitrogen and argon only. Of the 3205^{cc} total, 2020^{cc} would be nitrogen

and argon, and of this the 39^{cc} argon would be 1·93 per cent. Since, according to Kellas (Proc. Roy. Soc., vol. lix, p. 67, 1895), 100^{cc} of mixed atmospheric nitrogen and argon contains 1·19 per cent of argon, we see that in the diffused gas the proportion of argon is about half as great again as in the atmosphere. Argon then passes the india-rubber film more readily than nitrogen, but not in such a degree as to render the diffusion process a useful one for the concentration of argon from the atmosphere.—*Phil. Mag.*, Feb. 1900, p. 220.

2. *Influence of Water on the Combustion of Carbon Monoxide;* by G. MARTIN. (Abstract.) Chemical News, vol. lxxxi, No. 2095. Jan. 19th, 1900.—The author believes that the action of water in facilitating the oxidation of CO cannot be expressed by one equation, but consists of several reactions—one predominating at one time, another at another time, according to the amount of H_2O and O_2 present. This accounts for the lengthening out of the explosion wave when the quantity of steam or O_2 present is diminished. As regards the mechanism of the process, the author believes that the H_2O molecule, by its "attractive power" (evidences of which he sees in the great dissociating power of water,) alters the motion of the atoms in neighboring molecules. This intramolecular alteration in strain, together with the presence of free O, determines the reaction—much in the same way that finely divided gold, etc., causes the decomposition of H_2O_2. This view explains the action of H_2O in dissociating NH_4Cl vapors,—the motion of the atoms within the NH_4Cl molecule being altered by the attractive power of H_2O, and thus it dissociates. The author considers the last case analogous to "supercooling" in liquids.

3. *The combination of sulphur dioxide with oxygen;* by E. J. RUSSELL and NORMAN SMITH.—The authors have found that when a mixture of sulphur dioxide and oxygen acts on certain oxides, in addition to the absorption of the sulphur dioxide, part of the sulphur dioxide and oxygen combine forming sulphur trioxide, this being apparently due to the "surface action" of the oxide. The extent of this "surface action" varies with the nature and physical conditions of each oxide. No sulphur trioxide was ever found unless a simultaneous absorption of sulphur dioxide occurred; when manganese peroxide and sulphur dioxide, dried by phosphorus pentoxide, were brought together, no absorption took place, nor was any sulphur trioxide produced on the addition of dried oxygen.

If a mixture of dried sulphur dioxide and oxygen be passed over well-dried platinized pumice heated to 400–450°, very little sulphur trioxide is formed, and the drier the materials the less is the combination.—*Proc. Chem. Soc.*, p. 41, 1900.

4. *Determination of Radicles in Carbon Compounds.* By Dr. H. MEYER. Authorized translation by J. Bishop Tingle, Ph.D. 12mo, pp. x, 133. New York, 1899. (John Wiley & Sons.)—Dr. Tingle has done a good service in translating into

English Dr. Meyer's excellent "Anleitung zur quantitativen Bestimmung der organischen Atomgruppen." The quantitative side of organic chemistry, too often neglected in the laboratory, must receive a new impulse from this little book, and so must help forward investigation. G. F. B.

5. *The reflective power of metals and metallic deposits on glass surfaces.*—E. HAGEN and H. RUBENS have investigated this subject for wave lengths from 450 μ to 700 $\mu\mu$. The interesting conclusion is drawn, from the long list of substances examined, that the reflective power of pure metals, in general, increases with increasing wave-length. This fact appears very strongly in the case of gold and copper. Both metals show a very small reflective power for violet and blue light; while for the red rays of wave-length 700 $\mu\mu$ the reflective power of gold is as great as that of silver. The behavior of the various kinds of speculum metal was also considered. The mirrors employed by Rosse, Brashear and Schröder, which consist essentially of a mixture of copper and tin, possess essentially the same reflecting power, varying from 62 per cent at 450 μ to 68 per cent at 700 $\mu\mu$. The admixture of a small portion of nickel (in the case of the speculum metal of Brandes and Schünemann) lowers somewhat the reflecting power. The metal of Ludwig Mach, consisting of aluminum and magnesium in varying proportions, has a reflecting power between the same limits of wave-lengths of about 83 per cent to 83·4 per cent. Its reflecting power, therefore, appears to be independent of length of waves.—*Ann. der Physik*, No. 2, 1900, pp. 352–375. J. T.

6. *A Vacuum Electroscope.*—It has generally been assumed that a vacuum does not conduct electricity, and that electrostatic induction takes place in a highly rarified medium. H. PFLAUM seeks to show the truth of this assumption by direct experiment. With a highly exhausted vessel he shows that electrostatic effects occur to a high degree, and that no luminosity could be detected under powerful inductive action. The vacuum therefore appeared to act like a perfect insulator.—*Ann. der Physik*, No. 2, 1900, pp. 290–293. J. T.

7. *Rapid spark discharges.*—An investigation in this subject by H. T. SIMON is of interest in view of photographs of lightning which show successive discharges passing over parallel paths. The experiments were made with the Wehvelt interrupter. It was found that a spark follows the same path as a preceding one if the interval between the two does not exceed 0·0028 second. If this interval is larger the spark follows a new zigzag path. This time-interval appears to be independent of the length of the spark gap and of the material of the terminals.—*Gesellsch. Wiss. Göttingen*, 1899, pp. 183–186. J. T.

8. *The discharge of Electricity through Argon and Helium.*—R. J. STRUTT, of Trinity College, Cambridge, has made some interesting experiments on this subject and reaches the following conclusions :

"The peculiar interest of the gases argon and helium is in their monatomic characters. The view now generally taken is that the electric discharge is conveyed in all cases by ions, these ions being produced by a dissociation process of some kind. If this be admitted there can be no escape from the conclusion that the ions of monatomic gases are split up into something smaller. The above experiments make it sufficiently clear, I think, that these gases convey the discharge in a normal manner. If the potential-fall at the cathode is a measure of the energy expended in the ionization of the gas when effected by an electric field, the experiments show that the ionization of argon and helium is somewhat more easily effected than that of other gases. There are other reasons for thinking that the atomicity of an elementary gas is not an important feature in its facility of ionization. Thus mercury vapor was found by Thomson and Rutherford to conduct much more freely than air under the influence of the X-rays. Helium, on the other hand, conducts only about half as well as air.—*Phil. Mag.*, March, 1900, pp. 293–307. J. T.

9. *An Experimental Research on Some Standards of Light;* by J. E. Petavel.—The author has carried on, during the past three years, an extensive series of experiments, having as their object the investigation of the most valuable light-standards of the incandescent type. The requirements for a practical standard are summarized as follows: (1) The standard must remain constant for long as well as short periods. (2) It should be reproducible. (3) The light emitted should be as nearly as possible of the same spectral composition as that of the chief artificial lights now in common use.

Experiments with the electric arc have led the author to the following conclusions:

(1.) The intrinsic brilliancy of the crater of a silent arc is about 147 candle-power per square millimeter.

(2.) Even when the most favorable conditions are selected, and the intensity of current and the length of the arc are maintained constant, it is difficult to obtain consistent results. variations of over 5 per cent. being by no means unfrequent, The crater of the arc does not, therefore, possess the qualities required of a standard.

(3.) Variations in the size of the carbons, in the intensity and density of the current, in the length of the arc, and in the total power expended (as long as the arc is kept silent,) will not cause the intrinsic brilliancy to vary more than 10 per cent. on either side of the mean.

(4.) No sensible variation in the intrinsic brilliancy, and therefore in the temperature of the crater, is produced by placing the carbons in an enclosure maintained at over 900° C.

The experiments confirm the theory that the crater of the arc is at the temperature of volatilization of carbon.

The Lummer and Kurlbaum incandescent platinum standard was also made the object of careful trials, but the result was

reached that it does not possess the qualities required of a primary standard, although under certain conditions it may be of great value as a standard of reference.

Passing to the subject of the molten platinum standard, first proposed by J. Violle in 1881, the author concludes, after experimenting upon the fusion of platinum by an electric current and with the oxyhydrogen blowpipe, that the latter leads to the best results if the platinum selected is chemically pure, the crucible is made of pure lime, the hydrogen contains no hydrocarbons, and the gases are burnt in the ratio of four volumes of hydrogen to three of oxygen. The temperature of the flame, if the last condition is observed, is but little above the melting point of platinum, and the metal is not essentially superheated. A detailed account is given of the methods employed for attaining a high degree of accuracy, particularly in the photometric parts of the work, and a series of tables show the results reached; for details of these reference must be made to the original paper.

The final conclusion is important, viz., that under standard conditions the probable variation in the light emitted by molten platinum is not above 1 per cent, and with more perfect apparatus and somewhat better experimental conditions, the accuracy could be increased beyond this point. It is not impossible, even, that the accuracy of the platinum standard may attain to, or even surpass, the limit fixed by physiological conditions.—*Proc. Roy. Soc.*, lxv, pp. 469–503.

10. *A Text-Book of Physics;* by W. Watson, Assist. Professor of Physics at the Royal College of Science, London. Pp. xxii, 896. London 1899 (Longmans, Green & Co.).—The varied wants of different teachers of Physics have led to the publication of a long series of text-books, many of them of a high degree of excellence, though no two cover just the same field. Of this latest addition to the series it is possible to speak in terms of decided commendation. Many teachers, among those who have not written book for their own classes, are likely to find that it more nearly fills their wants than any one of its predecessors. It gives a clear, systematic and thorough presentation of the whole subject and from a rather advanced standpoint, though it does not assume the knowledge of more than the ordinary methods of mathematics.

The book is not an easy one for a large class of elementary students, certain portions, for instance the chapters on electricity, being rather difficult,—more so in fact than those on light, where the methods of geometrical optics are pretty closely adhered to. In the former case, the author seems to go almost too far in his admirable plan not to dwell too much upon the experimental side of the subject. Some students will wish that the printer had been a little more liberal in the use of italics, as it is a help to one approaching the subject for the first time to have the essential subjects and principles discussed brought at once clearly before the eye. It is also rather to be regretted that the pub-

lishers did not think it worth while to take a little more pains with the illustrations, which are not up to the level of the typographical work. Future printings will give the author an opportunity to correct an occasional slip, as for example, when he dates the first recognition of the phenomena of statical electricity from "about the commencement of the Christian era" instead of six hundred years before. One cannot but surmise that he may have been misled by a typographical blunder in recent editions of another well-known text-book.

II. Geology and Mineralogy.

1. *Geology of the Yellowstone National Park; Descriptive Geology, Petrography and Paleontology;* by Messrs. Hague, Iddings, Weed, Walcott, Girty, Stanton and Knowlton (Monograph xxxii, Part ii, U. S. Geol. Surv., 4to, pp. 791, Plates 121). Washington, 1899.—There is probably no area of equal size in this country to the geology of which so much popular interest attaches as the Yellowstone National Park. The very features to which it owes its existence as such, are those dependent upon its geological formation, and as year by year it is seen by a greater number of visitors and becomes better known, the Park serves to awaken interest not only in its own geology but in the science in general.

The appearance, then, of this great monograph containing the reports of the various well known specialists who have assumed different departments of the field of research, opened up by the exhaustive studies and collections made in the Park, will be greeted with more than ordinary attention. We regret that our space does not permit us to give the extended review that the work deserves, but that we must content ourselves with a brief notice of the more important portions of its contents.

The volume opens with a descriptive account by Iddings and Weed of the Gallatin Range and its geology. The sedimentary rocks ranging from the Cambrian upward to the Laramie have been uplifted, faulted, and intruded by igneous magmas in large laccolithic bodies, dikes and sheets. Erosion has laid bare the structures and later glaciation has modified the topography. The petrography of the igneous rocks is then described by Iddings, who shows that they are mostly fine-grained, porphyritic rocks of andesitic character. An occurrence of differentiation in an intrusive sheet by the settling of augite crystals is given. The third chapter is a description by Iddings of Electric Peak and Sepulchre Mountain and is practically a reprint of a former article noticed in this Journal (vol. xliv, p. 429, 1892). They are regarded as parts of a dissected volcano.

The northern end of the Teton Range projects into the Park and its geology is described by Weed and Iddings. It consists of a nucleus of gneisses and schists covered with Paleozoic and Mesozoic strata flexed in an anticline with northward dipping

axis and somewhat faulted. Upon these greatly eroded strata, basic breccias were piled up, eroded in turn and then came vast flows of rhyolite, which now form part of the Park Plateau and hide the northern end of the range.

In the fifth chapter Hague describes the geology of a mountainous area in the southern part of the Park, which consists of a number of ridges of northwest and southeast trend, mostly composed of Mesozoic rocks. The irregular outline of these mountains is due to the rhyolites of the Park Plateau that abut against the upturned beds. A few exposures of dacite occur in this area surrounded by rhyolite which they apparently antedate. Hot spring areas and localities of fossil flora are described. An interesting and important feature is the discovery of the former outlet of the Yellowstone Lake in Outlet Cañon through Chicken Ridge, which in former times served to drain the lake waters westward into the Snake River and so into the Pacific, instead of into Atlantic waters as at present. The chapter closes with a description of Two-Ocean Plateau, forming part of the Absaroka Range and composed of volcanic breccias and silts.

The southern end of the Snowy Range is described by Weed. It forms the northeast corner of the Park and its plateau-like summit of crystalline rocks is flanked by Paleozoic sediments which dip southward toward the Park. Detailed sections of these sediments are given. The highest peaks, as well as considerable areas, are formed by andesitic breccias lying on the Paleozoic rocks.

In Chapter VII, Iddings describes the Miocene volcano of Crandall basin, which was built up on eroded Paleozoic strata and earlier lava flows. It consisted of andesitic breccias topped by basalt flows and cut by dikes radiating from the central conduit, which was finally filled with magma; this became a mass of granular rock varying from gabbro to diorite and in part monzonite-like in character. In the outer flanks of the great volcano the breccias were fine and well-bedded; near the core they are coarse and chaotic. Comparison with modern cones of equal size like Etna shows the volcano rose over 13,000 feet above the Paleozoic floor. It is now thoroughly dissected by erosion and its interior laid open.

In the four following chapters Iddings describes the petrography of the types of igneous rocks found in the Park, the various kinds of andesites and andesitic breccias that so largely make up the Absaroka Range, the rhyolites which compose the great plateau, the basalts and certain rocks of peculiar composition found as dikes and small flows and classified as absarokites, banatites and shoshonites. These descriptions include in essence the former memoirs of the author on the rhyolite and glass of Obsidian Cliff (7th Ann. Rep. U. S. Geol. Surv., 1888, pp. 249–295) and on the peculiar dikes and flows (Jour. of Geol., 1895, p. 935).

The latter half of the volume is devoted to the Paleontology of the Park area and consists of three chapters, the Paleozoic fossils, the Mesozoic invertebrates, and the Mesozoic and Tertiary flora.

The Paleozoic sediments, clearly recognizable by their fossil contents, belong to the Cambrian, Devonian, and Lower Carboniferous terranes. The Cambrian fauna of about thirty species is described by the Director of the Survey, Charles D. Walcott. Several of the species are new to science, and one new genus, *Haguia*, is referred to a primitive type of *Archæocyathinæ*.

The Devonian and Lower Carboniferous collections are discussed by Dr. G. H. Girty. The Devonian fauna is a meager one, and the fossils are generally poorly preserved. The Madison limestone, representing probably the major portion of the Mississippian with Kinderhook affinities, contains a much richer and more varied fauna of seventy-nine species.

The Mesozoic invertebrates were studied by T. W. Stanton. Thirty-one species are recognized from the Cretaceous, forty-six from the Jurassic, and one from beds of supposed Triassic age. The Jurassic fauna is the most important, and in number of species it compares favorably with the Jurassic of other parts of the Rocky Mountain region.

The fossil flora of the Park by F. H. Knowlton forms the subject of the last chapter, and is an important geological and paleobotanical contribution. Eighteen species represent the Park Mesozoic flora as contained in the Laramie sandstones of the Cretaceous, no plants having yet been found from the Jura or Trias.

The chief points of geological interest arise from the fact that all the Tertiary plant remains occur in beds of volcanic origin, thus giving direct evidence of the age and period of some of the great igneous activities which are responsible for most of the marvelous geological phenomena of this region.

The older series of lavas, as determined by the geologists, have been designated as the early acid breccias and flows, while the younger series are known as the early basic breccias and flows. Both of these series contain ash beds probably deposited as mud flows. In these the plant remains have been preserved, each series being marked by different floral characteristics, with a subordinate intermediate flora in the upper early acid breccias.

The earliest flora, that of the early acid breccias, contains seventy-nine species, of which forty-two are new to science. Its affinities are shown to be with those of the Fort Union beds, though forms common to the Laramie, Green River, and Auriferous gravels are also present. The intermediate flora is related to that of the younger or basic series. The third flora, the one occurring in the early basic breccias, embraces seventy species, and is shown to have its closest relationships with the Auriferous gravels of California, now referred to the Upper Miocene Tertiary.

The noted fossil forests of the Yellowstone National Park form the subject of a separate section. They are undoubtedly the

most remarkable objects of their kind thus far discovered in any part of the world. They occupy more extensive areas than any other aggregation of fossil trees yet described, and, moreover, they are unique in retaining the trees standing upright in the exact positions in which they grew originally. The trees were largely conifers, and some of them attained gigantic proportions, though in the main the trunks will not average more than from two to five feet in diameter. Nearly all the localities show a succession of these silicified forests lying one above another. The primitive forest was buried under volcanic débris, probably at the time of an eruption, and gradually petrified by waters charged with silica. After a period of quiet, a second forest gained a foothold and flourished above the first. In its turn, the second was buried and silicified as the first had been. At the locality known as Fossil Forest, on Amethyst Mountain, this process of successive burial and renewal of the Tertiary forests was repeated through two thousand feet of volcanic material, and no less than fifteen forests were entombed. The mode of illustrating the species of trees constituting the fossil forests is somewhat novel, consisting of the usual photographs showing the minute structure of the wood, and others illustrating the fossil trunks as they appear in the Park, protruding from the volcanic deposits, and sometimes standing alongside of trees belonging to the existing flora.

In a section devoted to the biological consideration of the Tertiary flora of the Park many interesting comparisons are made with the present flora of the same region, and the deduction is made that then as now the coniferous type of tree predominated, though there was much greater variety during Tertiary time than now. The climate also was considerably warmer and approximated the conditions at present existing in Virginia.

L. V. P. and C. E. B.

2. *The Silurian Rocks of Britain.* Vol. I. *Scotland;* by B. N. Peach and John Horne. *With Petrological Chapters and Notes;* by J. J. H. Teall. Mem. Geol. Surv. United Kingdom, Vol. I, Plates i–xxvii, figs. 1–121, with map, pp. iii–xviii, and 1–749, 1899.—The present publication, forming the first volume of the Monographs of the Geological Survey of the United Kingdom, on the Silurian Rocks of Great Britain and Ireland, is devoted to the Silurian formations of Scotland. It presents a detailed summary of all that is known up to the present time regarding these early records of the geological history of the country. This volume is a continuation, in style and size, of the "Memoirs of the Geological Survey of Great Britain and of the Museum of Economic Geology in London;" the first volume of which was published in 1846, and Volume III, 1st edition, was published in 1866, by the Director-General Murchison, and a second edition of it appeared in 1881, by Director Ramsay. Many new facts are reported worthy of special notice, to some of which we hope to give attention in a future issue.

This volume is of more than ordinary interest, and worthily stands as the first of a new series of publications, the Monographs of the Geological Survey. The researches reported in it combine stratigraphical, petrographical and paleontological studies of the most thorough kind, of a very complex series of rocks much disturbed by folding and faulting and with igneous intrusions. Messrs. Peach and Horne, the chief authors of the volume, began the study of the southern uplands geology in 1888, having as a clue for the interpretation of the stratigraphy the results of Professor Lapworth's studies, particularly the carefully established succession of graptolites. They make special reference to the value of Professor Lapworth's results as well as his method of investigation, at the close of the second chapter. Mr. J. J. H. Teall contributes valuable chapters on the petrography of the igneous rocks, the granite masses, and on contact metamorphism. Several specialists, both within and outside the Survey, contribute both assistance and advice. Not least among these is Mrs. Robert Gray, whose superb collection of 30,000 specimens of the Silurian fossils of the Girvan district was first placed at the service of Messrs. Nicholson, Etheridge and Lapworth; it was again at the disposal of the Survey; and in the Appendix is published a list of the fossils with their range and distribution, prepared by Mrs. Gray.

The value of the report is heightened for the general reader by the chapter (II) giving a concise, but full, history of previous researches among the Silurian rocks of the south of Scotland, beginning with Hutton in 1795. The recapitulation of the results of the investigations of the Geological Survey in the southern uplands will indicate some of the more important problems here discussed in detail:

"1. The occurrence of a series of Arenig volcanic and plutonic rocks on various anticlines over an area of about 1500 square miles.

"2. The existence of a well-marked band of radiolarian cherts and mudstones, overlying the foregoing volcanic series, which has been traced over a part of the uplands measuring about 2000 square miles.

"3. The main band of radiolarian chert and mudstone, though about 70 feet thick, represents the succession of deposits which, elsewhere in Britain, intervene between the Middle Arenig and uppermost Llandeilo strata.

"4. The occurrence at various localities over a limited area of volcanic rocks of Llandeilo and Caradoc age.

"5. During the examination of the various black shale outcrops throughout the uplands, a great amount of detailed evidence has been obtained, confirming the order of succession established by Professor Lapworth, and the lateral variation of the strata between Moffat and Girvan.

"6. The inclusion of the Downtonian strata of Lanarkshire and the Pentland Hills in the Silurian system, owing to the discovery

of fishes, eurypterids, etc., resembling those occurring in the Ludlow rocks of Lanarkshire and other regions." W.

3. *Lower Cambrian Terrane in the Atlantic Province;* by CHARLES D. WALCOTT. Proceedings of the Washington Academy of Science, Vol. I, Plates XXII–XXVI, figs. 9–11, pp. 301–339, 1900.—The study of the New Brunswick and Newfoundland lowest Paleozoic rocks has led Mr. G. F. Matthew to the establishment of a basal or Etcheminian series of rocks of supposed pre-Cambrian age, and the adoption by him of a classification which recognized only two divisions of the Cambrian, an Upper Cambrian (Potsdam with Olenus fauna) and a "Lower" Cambrian (with the Paradoxides fauna), equivalent to the Middle Cambrian, or Acadian, but including the subjacent Protolenus fauna, which he regarded as equivalent to the Olenellus fauna of the Georgian or Lower Cambrian.

Mr. Walcott, after exhaustive study of the original sections upon which Mr. Matthew's interpretations were made, both in Newfoundland and New Brunswick, establishes the following conclusions:

"(*a*) The 'Etcheminian' terrane of Matthew is of Lower Cambrian age.

"(*b*) The Olenellus fauna is older than the Paradoxides and Protolenus faunas of the Middle Cambrian.

"(*c*) The Cambrian section of the Atlantic Province of North America includes the Lower, Middle, and Upper Cambrian divisions as defined by me in 1891."

These are supported by the following facts:

"(*a*) That the Olenellus fauna in Newfoundland occurs 420 feet beneath the Paradoxides fauna, in the heart of the Lower Cambrian 'Etcheminian.'

"(*b*) That fragments of the fauna are found 460–480 feet below the Protolenus fauna in the 'Etcheminian' of the Hanford Brook section of New Brunswick.

"(*c*) That in the undisturbed, unbroken Highland Range section of Nevada the Olenellus fauna is 4450 feet below the Upper Cambrian fauna, and that the Olenoides (Dorypyge fauna of Matthew) is 3000 feet below the horizon of the Upper Cambrian fauna and 1450 feet above the horizon of the *Olenellus gilberti* fauna.

"(*d*) That in the southern Appalachians the Olenellus fauna occurs more than 7000 feet below the highest Cambrian fauna known in that region, and fully 2000 feet below a typical Olenoides fauna." W.

4. *Geological Survey of Canada*, GEORGE M. DAWSON, Director.—Accompanying three sheets of a revised edition of the Geological map of the Sidney Coal field (sheets 133, 134, and 135; new numbers, 652, 653, and 654), the Survey publishes a Descriptive note on the Sydney Coal field, Cape Breton, Nova Scotia (No. 685). The Barachios slates are reported as Cambrian (from Etcheminian to Lingula Flags), according to determi-

nations of Dr. G. F. Matthew. The "Carboniferous conglomerate series," lying below the Carboniferous limestone series, was formerly correlated with the Devonian or Old Red sandstone o England. The Carboniferous limestone series underlying the Millstone grit occasionally holds marine fossils. W.

5. *Das geotektonische Problem der Glarner Alpen;* von A. Rothpletz. Pp. 251. Atlas of x plates and one colored map. Jena, 1898 (Fischer).—The complicated structures of the Glarner Alps, southeast of Zurich, have been explained as the result of a remarkable pair of folds whose crests lean towards each other from the north and south, covering a pouch-like trough; Heim being the chief exponent of this view in his celebrated "Untersuchungen ueber den Mechanismus der Gebirgsbildung" (1878). For some fifteen years past, Rothpletz of Munich has been studying this difficult region, and his results contradict the conclusions previously announced. His latest essay, of title as above, leads to the following summary: The undermost or basal mountain mass consists of a series of closed folds of all formations from gneiss to Oligocene; the folds lean over to the northwest. This basal mass has been completely covered by overthrusts, and is to-day laid bare only in deeply eroded valleys. The first overthrust, a deformed mass of all formations from gneiss to Eocene, was driven over the basal mass from the east. Two later overthrusts were shoved on from the northwest. The overthrust masses have been splintered and wedged; the thrust surfaces have been severely scoured; the composite mass has been deeply eroded, and the overthrusts here mentioned as single masses are to-day dissevered. The sources of the overthrust masses lies outside of the field of study and must be searched for by further exploration. Longitudinal and cross faults have disturbed the composite structure. Some of the cross faults are associated with valleys; those of the Linththal in particular are stated to have produced a *graben*-like depression by which the direction, breadth and depth of the existing valley have been determined.

At this distance from a field in which controversy has been ardently carried on by local experts, it is not advisable to attempt a judgment on so difficult a problem as the structure of the Glarner Alps. One observer says that his criticisms of earlier work have fallen on deaf ears; an earlier observer replies that his critic has made inaccurate observations. While deprecating the polemic thus aroused, we may hope that many will follow the example of one of these geologists who announces that he will for the present lay down his pen and take up his walking stick, with the promise of reporting further observations and conclusions at a later time. W. M. D.

6. *Ore Deposits of the United States and Canada;* by J. F. Kemp; 3d ed., 8vo, pp. 481. New York City, 1900. (The Scientific Pub. Co.)—The great development of mineral resources during recent years has resulted not only in opening new, extensive and varied fields to industry, but has afforded

excellent opportunity for the scientific study of ore-deposits from both a practical and theoretical standpoint. So rapid has been the advance along this line, especially in the United States, that hitherto the student has found the text-books on the subject rapidly becoming antiquated, and unless possessed of considerable time and facilities for extensive reading of the literature, has been compelled to labor at a disadvantage.

Professor Kemp has succeeded admirably in filling this deficiency in the literature of this subject, in the volume before us. In this he has to a large extent rewritten the former edition of his book on ore-deposits, and made very considerable additions of new material. It is a work the value of which will be appreciated by all who have occasion to use it, containing, as it does, a concise yet comprehensive and thoroughly up-to-date description and consideration of the ore-deposits of the United States and Canada.

Part I is introductory in its nature, its chapters being devoted to such brief considerations of geology—of the formation of cavities for the reception of ores; of the minerals forming ores; of the facts and theories concerning the methods of their deposition; of the structure of veins and the classification of ore-deposits—as are necessary for an intelligent reading of the descriptions of Part II. The author has, and we think wisely, included here only a single broad scheme of classification based largely on origin, and in accordance with the results of the most recent investigation. The presentation and discussion of the numerous other classifications, which if included in the text might lead to confusion, are referred to the Appendix.

Part II deals directly with the principal ore-deposits themselves, classed under the heads of the appropriate metals. In presenting the theories relating to the genesis of the ores, excellent judgment has been shown in giving only such as have a substantial basis in observed facts and in omitting all those more or less fanciful theories which so often burden the literature on this subject. The descriptions in the text are supplemented by excellent half-tone engravings, maps and diagrams taken from various sources. Especial mention might be made of those illustrating the occurrence of the Lake Superior iron ores, the mineral lodes of Butte City, Mont., and those of Alaska.

The full lists of references to the literature on ore-deposits, distributed throughout the book, will certainly be of great value to anyone desiring a more thorough and extended knowledge of this subject. C. H. W.

7. *The Ward-Coonley Collection of Meteorites.* Pp. 100, plates VI. Chicago, 1900.—The collection of meteorites described in this catalogue has been brought together by Professor H. A. Ward and includes some 424 independent occurrences. It thus ranks as one of the very large collections of the world. It is also remarkable in the total weight as too in the size of the individual specimens. The aggregate weight amounts to 1400

kilos (over 3,000 pounds), while the average weight of each kind is 3·3 kilos (7¼ pounds). Each specimen is described and a series of six plates, most of these of etched plates, adds to the value of the volume.

III. Miscellaneous Scientific Intelligence.

1. *Earthquakes in Japan.*—A recent number of the Journal of the College of Science of Tokyo (vol. xi, pt. iv) contains the Earthquake Investigation Committee catalogue of Japanese earthquakes since the earliest times, by the late Prof. Sekiya. This report is discussed in the article following by Prof. Omori, with respect to the number of earthquakes, their chronological distribution, variation with the season, and other points. The total number of *destructive* earthquakes in Japan from the year 416 A. D. to the end of 1898 is 222. Of these, but few were recorded in the fifth, sixth, and seventh centuries, probably because of the imperfection of historical records in those earlier times. Beginning, however, with December 678, there are recorded 220 destructive earthquakes in the interval of 1220 years to the end of 1898, or one for about every five and a-half years. Were the records of earlier parts of this period more complete, this interval would undoubtedly be shorter. In the interval of nearly 300 years, from the beginning of the seventh century to the end of 1898, there were 108 destructive earthquakes in Japan; from which it is concluded that one part or another of Japan (except Formosa) is likely to be visited, on the average, once in nearly two and a-half to three years.

With respect to the distribution through the year, it is found that of 216 destructive earthquakes, 48 occurred in the spring, 74 in the summer, 49 in the autumn, and 45 in the winter. The maximum monthly number of 32 occurred in August, and the minimum of 10 in January. The frequency of ordinary small shocks, however, is found to be a minimum in the months of June, July, August, and September; in other words, just the reverse of the severe earthquakes. This fact, however, admits of explanation, as shown by the author, since the constant occurrence of small earthquakes in an unstable country like Japan may be regarded as maintaining the region in a normal safe condition, thereby preventing any abnormal condition of stress in the earth's crust. Their non-occurrence, however, may cause an accumulation of stress, facilitating the occurrence of destructive seismic disturbances.

Discussing graphically the distribution of the earthquakes in Japan from the eighth century on, it is found that this is not uniform but rather in groups; in other words, that destructive earthquakes, while sometimes happening isolated, tend to occur in groups in epochs of maximum frequency. The geographical distribution of the earthquakes in the different parts of the country is also minutely discussed.

2. *On the Propagation of Earthquake Motion to great Dis-*

tances; by R. D. OLDHAM, Geological Survey of India. (Abstract.) —When preparing a report on the great Indian earthquake of 12th June, 1897, the author noticed that the European records of this earthquake showed a phase of increased disturbance in what are commonly called the preliminary tremors, making, with the great undulations, three phases of motion. He suggested that these three phases represented the arrival of (1) the condensational, (2) the distortional waves traveling through the earth, and (3) surface undulations traveling round the earth. The present paper is an attempt to verify these suggestions by a comparison with other earthquakes.

For this purpose a selection has been made from the published records of those earthquakes which fulfil the conditions (1) that the place of origin shall be known within 1° of arc, (2) that the time of origin shall be known within a limit of error of one minute, (3) that there shall be a sufficient number of records, distant more than 20° of arc from the origin, to serve as a check on each other. Eleven distinct shocks, representing seven great earthquakes, are found to satisfy these conditions, and in every case the same three-phase character as was recognized in the earthquake of 12th June, 1897, is found. A comparison of time intervals and apparent rates of propagation shows that the coincidence is not accidental, but represents the separation of three distinct types of wave motion having different rates of propagation.

On plotting the records it is found that the time curves of the first two phases form curved lines, indicating an increase of apparent velocity with distance from the origin, such that, applying Rudzki's investigation, the wave motion represented by these two phases must have traveled through the earth, along curved wave paths, convex towards the center of the earth, and with a rate of propagation which increases with the distance from the surface. On continuing these curves, by extrapolation, to the origin, they give rates of propagation in very fair concordance with the rates of propagation of condensational and distortional plane waves which may be expected to obtain in continuous rock at some distance from the surface of the earth.

The waves of the third phase show no such increase of rate of propagation with distance from the origin. The rate of propagation is uniform at all distances; from which it is concluded that the great undulations of the third phase are surface waves, traveling with a uniform rate of propagation round the surface of the earth. It is also found that the waves of this phase set up by great earthquakes travel faster than those set up by lesser ones, and from this it is concluded that the rate of propagation of these waves is in some way a function of their size, thus affording a confirmation of Lord Kelvin's suggestion that their propagation is in part gravitational.

The general conclusion is that in the complete record of a distant earthquake, three distinct types of wave motion can be

recognized: (1) condensational, and (2) distortional plane waves, traveling by brachi-stochronic paths through the earth, and (3) elastic, or gravitational elastic, surface waves, traveling round the surface of the earth. The records are, however, often incomplete by the omission of the first or the first and second of these phases, and the widely divergent estimates of the apparent rate of propagation of the preliminary tremors are largely due to this.—*Proc. Roy. Soc.*, lxvi, 2, 1900.

3. *On Earthquake Sounds.*—Dr. C. DAVISON closes an interesting paper in a recent number of the Philosophical Magazine with the following discussion as to the *origin of earthquake sounds:* "In any earthquake there are generally three well-defined stages of motion—the preliminary tremor, the principal portion, and the end portion. In the first, the characteristic movements are small in amplitude and short in period; the second and most active part of the disturbance consists chiefly of vibrations of larger amplitude and longer period; and these are followed by the feeble movements which constitute the end portion. Slow undulations, with a period of about one-half to two seconds, may, however, be present in all three stages; while the ripples, with a period of one-tenth of a second or more, may be superposed on the slow undulations in the second and third stages as well as in the first. The average period of the ripples, it is important to notice, is slightly greater during the principal portion than during the other two stages.

During the earlier part of the movement there is a distinct increase in the period of the vibrations; and this has led some seismologists (all at the time living in Japan) to suggest that the first recorded tremors may be the successors of those which produce the preliminary earthquake-sound. The observations of British earthquakes show, however, that the sound-vibrations are not confined to the earlier stage, but that, like the ripples, they are also superposed on the slow undulations which form the main feature of the principal and end portions of an earthquake.

Some of the phenomena of earthquake-sounds, as we have seen, are due to the neighborhood of the sound to the varying lower limit of audibility. There are others, such as the time and space-relations of the sound and shock, for which a different explanation is required, and whose origin is of a geological rather than a physical character.

The theory which follows is based on the supposition that the majority of non-volcanic earthquakes are due to the gradual, but intermittent, growth of faults; the immediate cause of the disturbance being the friction produced by the slipping and rubbing of one of the adjoining rock-masses over and against the other.*

* The principal facts in favour of the fault-slip theory are:—(1) The elongated forms of the isoseismal lines, the longer axes of which in any district are, as a rule, either parallel or perpendicular to one another, and parallel, or nearly so, to the chief lines of fault; (2) the formation of fault-scarps concurrently with violent earthquakes; (3) the impossibility of a great fault growing otherwise than by an almost infinite number of slips; and (4) the enormous excess of the number of earthquakes over the number of faults in any one district.

A fault-slip does not of necessity take place concurrently all over the focus or instantaneouly at any one point of it. But, as a general rule, it certainly occupies a very short interval of time, and at places near the epicentre the duration of the sensible part of an earthquake must be mainly due to the size of the focus and the finite velocity of the earth-waves.

The seismic focus is practically a surface inclined to the horizon, and is often of great length in a horizontal direction. In its simplest form there will be a central region of the fault-surface where the relative displacement of the two rock-masses is a maximum, and this will be surrounded by a region in which the relative displacement is small, and gradually dies away towards the edges. As the vibrations of great amplitude are also of long period, we may consider that from all parts of the focus there start together vibrations of various amplitude and period, the large and slow undulations coming mostly from the central region, and the small and rapid vibrations of those which bound it. It is, I believe, from these marginal regions, and especially from the upper and lateral margins, that the more sensible sound-vibrations chiefly come. I will now endeavour to show how the phenomena of earthquake-sounds can be explained on this theory.

If there is no discontinuity in period between the large vibrations which come from the center of the area and the sound-vibrations from the focal margins, it is evident that among the vibrations must be included those which produce the deepest sound that can be heard by the human ear. The rumbling character of the sound may be due partly to its neighbourhood to the lower limit of audibility, partly, no doubt, to irregularities in the fault-surface producing local vibrations in the initial disturbance. To the latter cause may also be owing the intermittent sounds heard by some observers.

But whether there be any slight fluctuations in amplitude and period, or not, it is evident that the average intensity of the sound must gradually increase until the shock is felt ; and as soon as it is over, or nearly over, must gradually die away. At the same time the greater amplitude of the vibrations from near the central part of the focus will render audible vibrations of longer period than those which come from the margins; and thus the depth of the sound will increase and decrease with the intensities of the sound and shock. Especially will this be the case with the vibrations from the neighbourhood of that part of the focus where the initial amplitude is greatest; and the strongest vibrations and loud explosive crashes audible to some persons should therefore be observed concurrently.

Similar reasoning leads to the conclusion that the intensity of the sound should increase with that of the shock in different earthquakes, and that the sound should be deeper with strong shocks than with weak ones. But while the marginal vibrations are limited in period and amplitude, those from the central parts of the focus have a much wider range. With very weak shocks the

sound should be the most prominent feature; with very strong ones the sound, though actually louder, should be relatively insignificant; and when, as in the Hereford earthquake, the earthquake consists of two distinct parts, the two shocks may differ widely in intensity, while the accompanying sounds may be almost equally loud.

With observers of given average auditory powers, the magnitude of the sound-area depends on the limited strength of the marginal vibrations, and on the dimensions of the seismic focus, and therefore of its marginal regions. The magnitude of the disturbed area depends partly on the size of the focus, chiefly perhaps on the initial intensity of the vibrations from its central portion. While the dimensions of the sound-area should generally increase with those of the disturbed area, it is evident that they should not increase in the same ratio. With very strong shocks, the sound-area should be a comparatively small district surrounding the epicentre. With very slight ones, the marginal regions would be so great compared with the central portion of the focus, that the sound-area might overlap the disturbed area. In the limit, the central portion of the focus would vanish, and an earth-sound would be the only result sensible to human beings.*

Several of the phenomena of earthquake-sounds depend on the superficial form and inclined position of the focus, and on the fact that the most sensible sound-vibrations come from the upper and lateral margins. The isacoustic lines and the boundary of the sound-area should not be concentric with the isoseismal lines. Relatively to the latter the sound-area will be shifted towards the fault-line, and also in a direction parallel to it, if one lateral margin should predominate over the other.

The time-relations of the sound and shock remain to be considered. The sound-vibrations from the margin nearest to the observer should be heard before the shock begins, those from the upper margin, and possibly from parts of the central portion, during the progress of the shock, and those from the furthest margin after the shock ends. Moreover, the sound-vibrations from the nearer lateral margin will be of greater intensity than those from the further one; and thus the fore-sound should be more generally heard than the after-sound, and with Japanese and some other observers should be the only one perceptible. The percentage of observations of the after-sound should also diminish with the increasing distance from the origin; and the duration of the sound, especially near the epicentre, should be greater than that of the shock.

At places near the epicentre, and also at the places whose distances are great compared with the dimensions of the focus, the sound-vibrations which appear loudest will be those which origi-

* It has been suggested that the comparative smallness of the sound-area may be due to the more rapid extinction of the sound-vibrations; but the explanation is clearly incomplete, for it fails in the cases in which the sound-area overlaps the disturbed area.

nate near the central portions of the focus; and thus the epochs of maximum intensity of the sound and shock should coincide. If, however, the horizontal length of the nearer focal margin be considerable, the sound which seems loudest to observers at a moderate distance may come from or near that margin; for there is but little change in the initial intensity of sound-vibrations from the neighbourhood of the central portion. To observers who are situated near the continuation of the line of fault, the maximum epoch of the sound will therefore precede that of the shock; while to those who are near the minor axis of the isoseismals, the two epochs will approximately coincide."

4. *On the origin of Gulf Stream water;* by P. T. Cleve. (From the Öfver. Vet. Akad. Förhandlingar, 1899. No. 9. Stockholm.)—Hydrographers understand by "gulf-stream water" such water in the northern Atlantic as contains about 35, or rather more, p.m. of salt. The name indicates that it is supposed that such water is derived from the gulf-stream, or the surface-current, which runs from the Gulf of Mexico. The study of the geographical distribution of the plankton-organisms has convinced me that such a supposition is, at least for the greater bulk of gulf-stream water, erroneous and that the gulf-stream water comes into the northern Atlantic along the west coast of Africa and between the Azores and Europe. This is in direct opposition to all surface-currents, so it must be admitted that the gulf-stream water moves as an under-current. I know a number of plankton organisms, which all point to the above conclusion. Samples from the Benguela current, for which I am indebted to the kind assistance of Doctor Van Doesburgh on the Fregatte Atjeh of the Dutch Navy, make it more than probable that the gulf-stream water reaches the Atlantic round the Cape of Good Hope.

I have comprised under the name *styli-plankton* such organisms as inhabit the gulf-stream water of the hydrographers. The number of such forms, known to me at present, is very considerable, but I will here treat of the distribution of a smaller number only, selecting some of the typical species. Some of these styli-plankton organisms are confined exclusively, or nearly so, to the eastern Atlantic. Some have a very wide range of distribution and occur both in the eastern, western and northern Atlantic, or round the Sargasso Sea.

It will be found from the following data that such styli-plankton organisms as have a very wide range of distribution follow both the eastern side of the Atlantic, or along the coasts of Africa between the Azores and Europe, and the equatorial current towards South America into the Caribbean Sea, and thence the Antilles and Florida currents towards the Newfoundland banks and farther to about 45° to 50° N., where they seem to unite with those coming from the east Atlantic. They proceed then to the north, towards Iceland and the Färöe Channel, and a small number finally reach Spitzbergen. . . .

The species, whose distribution is discussed in detail, are as follows: *Corycæus rostratus, Clausocalanus arcuicornis, Acartii Clausii, Centropages typicus, Dictyocysta elegans, Undella candata, Chætoceros skeleton, Dactiosolen antarcticus, Challengeria xiphodon.* The author adds: "All the above data, which I could easily multiply, prove beyond doubt that the gulf-stream water, proceeding from the east of Africa towards the Azores and the European coast, expands above the 40° N. so far to the west as to approach the American coast. From 40° N. it advances to the north, to Iceland and the Färöe Channel. It turns in September to the north of Iceland. From the Färöe Channel it flows into the North Sea and, as will be shown further on, towards Spitzbergen.

In the following I will treat of some styli-plankton forms with a very wide range of distribution, in order to show that the styli-plankton also follows the South Equatorial current to S. America as well as into the Caribbean Sea, and the Antilles and Florida currents towards the north." . . .

Hear are included *Paracalanus parvus, Coscinodiscus* (*Planktoniella*) *Sol., Rhizosolenia styliformis.* The author concludes: "The range of distribution of *Rhizosolenia styliformis* fairly indicates the area within which the styli-plankton occurs. Although of so wide a range it has been very rarely seen in the Sargasso Sea, round which the styli-plankton water occurs.

In March–May the styli-plankton extends along 50° N. from America to the English Channel. Already in April this area has advanced to 60° N., in June to Iceland. From that island it spreads on the east to the Shetlands, on the west to Greenland, where rare specimens follow the east Greenland current and are conveyed in October into Davis Strait. Other specimens follow the current to the north of Iceland in September, others drift to Spitzbergen, where they already appear in August."

5. *Annals of the Astronomical Observatory of Harvard College*, Edward C. Pickering Director.—The recent publications of this valuable series are as follows:

Volume XXXII, Part II, contains Visual Observations of the Moon and Planets, by William H. Pickering, carried on for the most part at the station near Arequipa. Volume XXXIII contains Miscellaneous Researches made during the years 1894–1899 by different observers; these include Photometric Observations of Asteroids, Observations of Variable Stars, Nebulæ, Comets, etc. Volume XLII, Part II, contains the Observations made at the Blue Hill Meteorological Observatory in 1897 and 1898, under the direction of A. Lawrence Rotch. These are concerned chiefly with Cloud Observations under varying conditions. Volume XLIV, Part I, contains a Photometric Revision of the Harvard Photometry during the years 1891–1894, by Edward C. Pickering.

6. *Publications of the Yerkes Observatory, University of Chicago.* Volume I, pp. 296. *A General Catalogue of 1290 Double Stars;* by S. W. Burnham. Chicago, 1900.—The appearance of

the first volume of the publications from the Yerkes Observatory is a notable event. It contains the catalogue of the double stars discovered by Prof. Burnham from 1871 to 1897, arranged in order of right ascension, with all the micrometrical measures of each pair. The Introduction contains a description of some of the instruments employed by Prof. Burnham, accompanied by a series of plates; one of these, the frontispiece, shows the great 40-inch Clark telescope of the Yerkes Observatory.

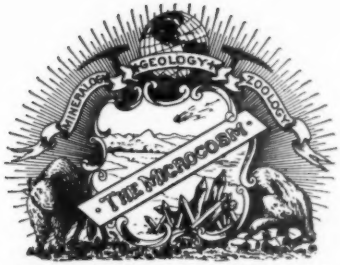
7. *La Géographie, Bulletin de la Société de Géographie.*—The Société de Géographie of Paris has inaugurated, with the opening of this year, a new journal called La Géographie, which is to be published on the 15th of each month; it will include in expanded form the formerly issued *Bulletin trimestriel* and *Comptes Rendus.* Each number will contain some eighty pages, large octavo, including original memoirs, a bulletin of geographical news, a bibliographical index, and a *compte rendu* of the meetings of the Society. It will be illustrated with plates and figures in the text. The members of the Society who are chiefly concerned in editing the new journal are Baron Hulot and M. Charles Rabot. Two numbers have already been received: these contain a series of interesting articles; thus, two papers by Gen. Gallieni upon Madagascar and its resources; an account of a trip across Corea by Marcel Monnier; results of the Belgian Antarctic expedition by E. Racovitza, and others of like value.

8. *Biological Laboratory of the Brooklyn Institute of Arts and Sciences.*—It is announced that the eleventh annual session of the Biological Laboratory of the Brooklyn Institute at Cold Spring Harbor, Long Island, will be held during the months of July and August, 1900. The regular class work will begin on Wednesday, July 4th, and continue for six weeks. The laboratory will be open for work from July 2d until August 25th. Investigators may make arrangements for using the laboratory from the middle of June until the middle of September, or later, if desirous of doing so.

The Director of the Laboratory is Prof. Charles B. Davenport of the University of Chicago. The course of instruction includes zoology with comparative anatomy, and embryology and botany with ecology and bacteriology; advantages are also offered to students in other directions. Those desiring further information are referred to the Director (Chicago) or to Prof. Franklin W. Hooper, 502 Fulton street, Brooklyn.

9. *Royal Academy of Sciences at Berlin.*—The 200th anniversary of the foundation of K. Akademie der Wissenschaften at Berlin was celebrated with appropriate ceremonies on the 20th of March. The following new foreign correspondents from the United States were appointed: Prof. J. Willard Gibbs of New Haven, Prof. Henry A. Rowland of Baltimore and Prof. William James of Cambridge.

La riduzione progressiva della variabilita e i suoi rapporti coll'estinzione e coll'origine delle specie, di Daniele Rosa, pp. 3–133, 1899.



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(1) Described in this Journal Sept., 1895. (2) Ibid Nov., 1887. (3) Proc. Roch. Acad. Sci. Vol. I. (4) This Journal Aug., 1888. (5) Ibid July, 1893. (6) Ibid June, 1894. (7) Ibid Nov., 1892.

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